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with Electronics Supplement

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VOLUME XVI

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Outlook for the British Industry

Plastics in Rocketry • Undercarriages and Tyres

No. 9 / 1961

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Volume XVI

INTERAVIA

September 1961

WORLD REVIEW OF AVIATION AND ASTRONAUTICS

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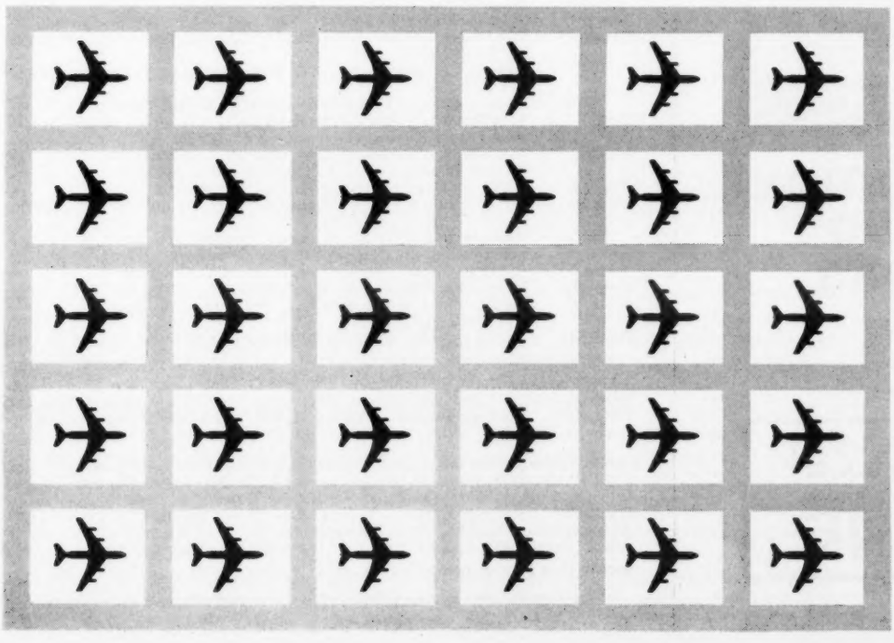

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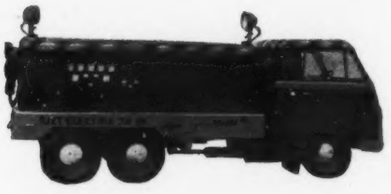

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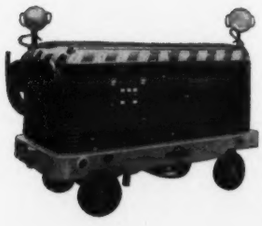

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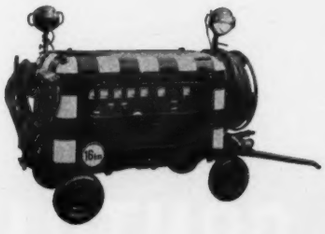

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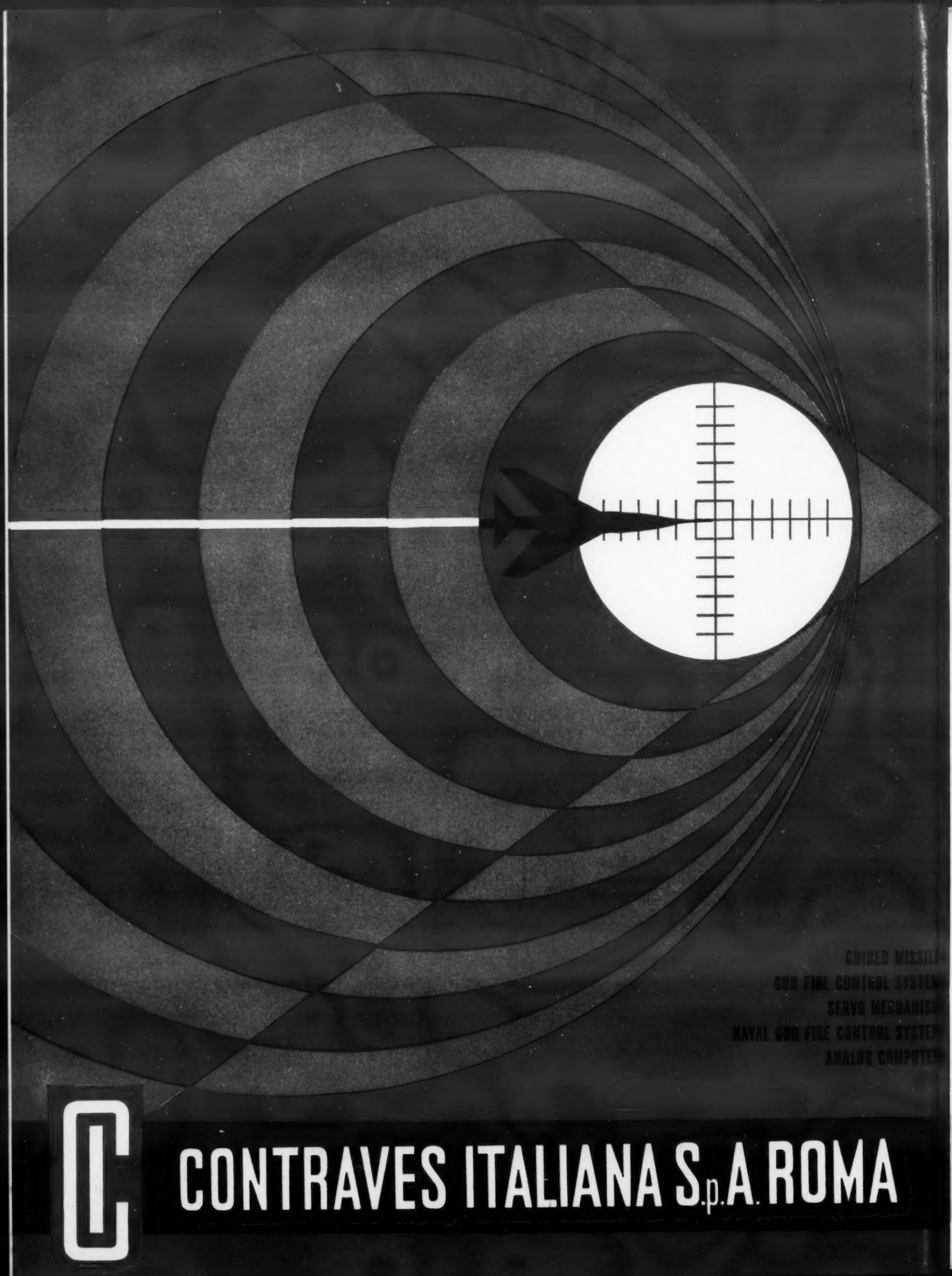

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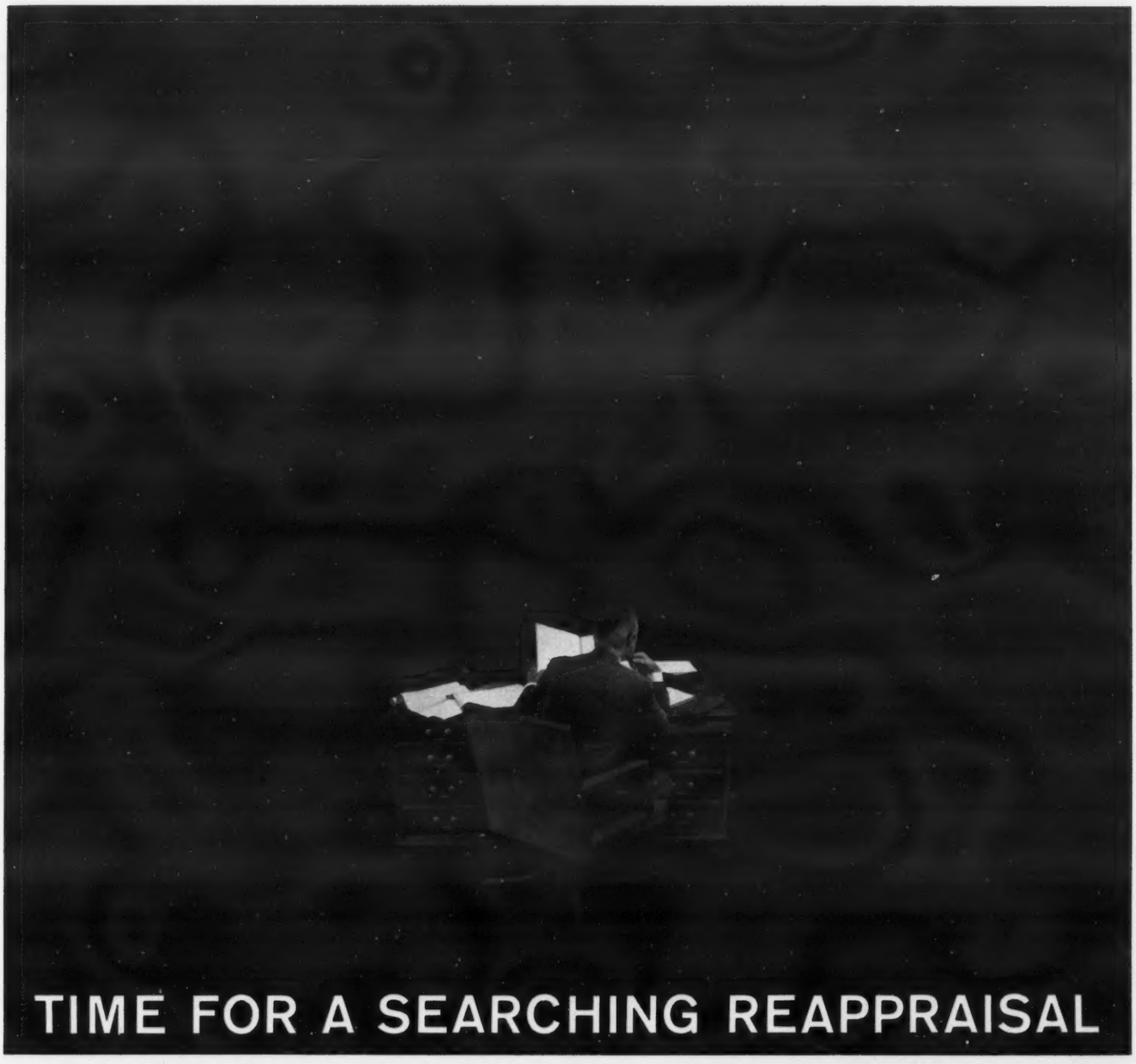

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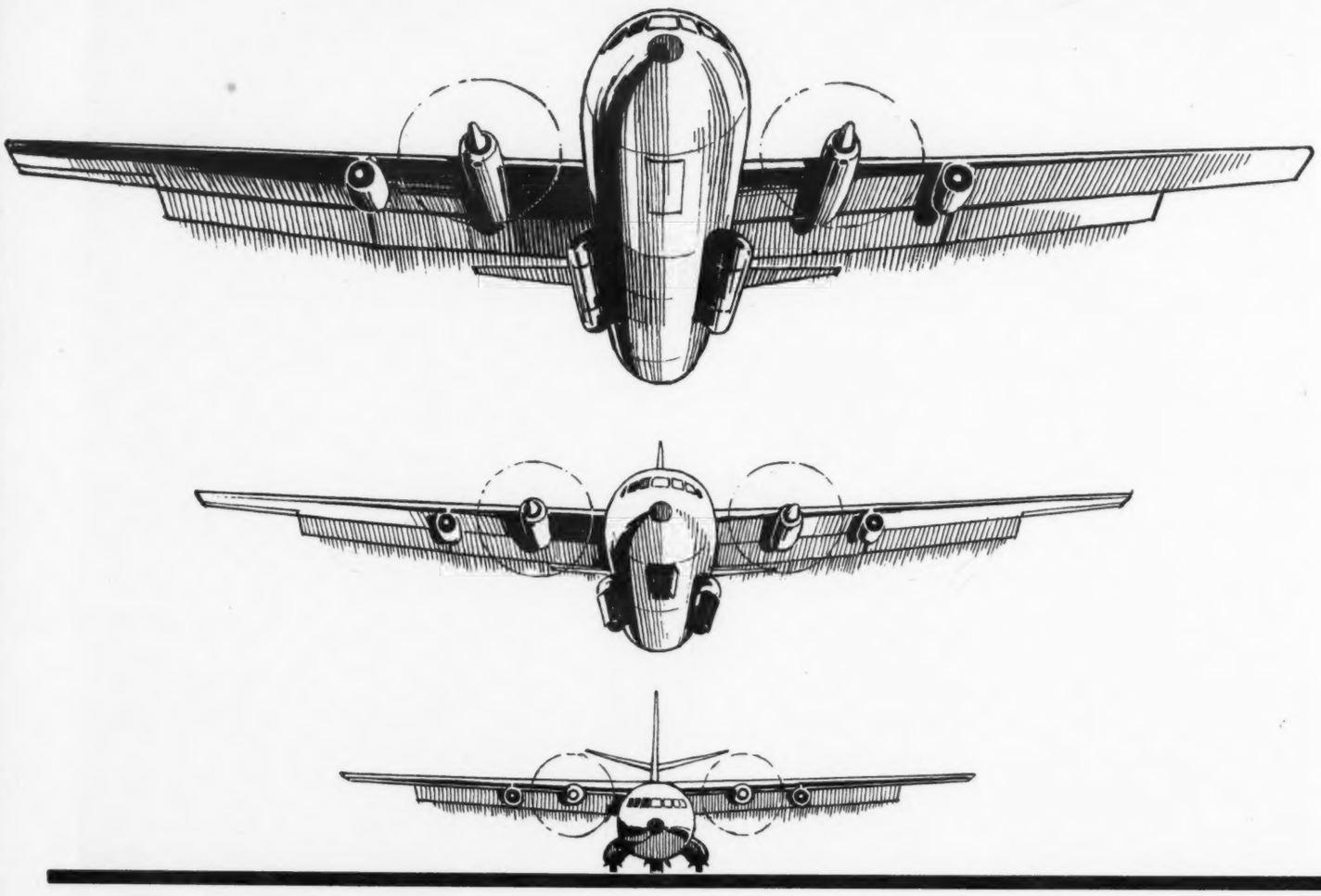

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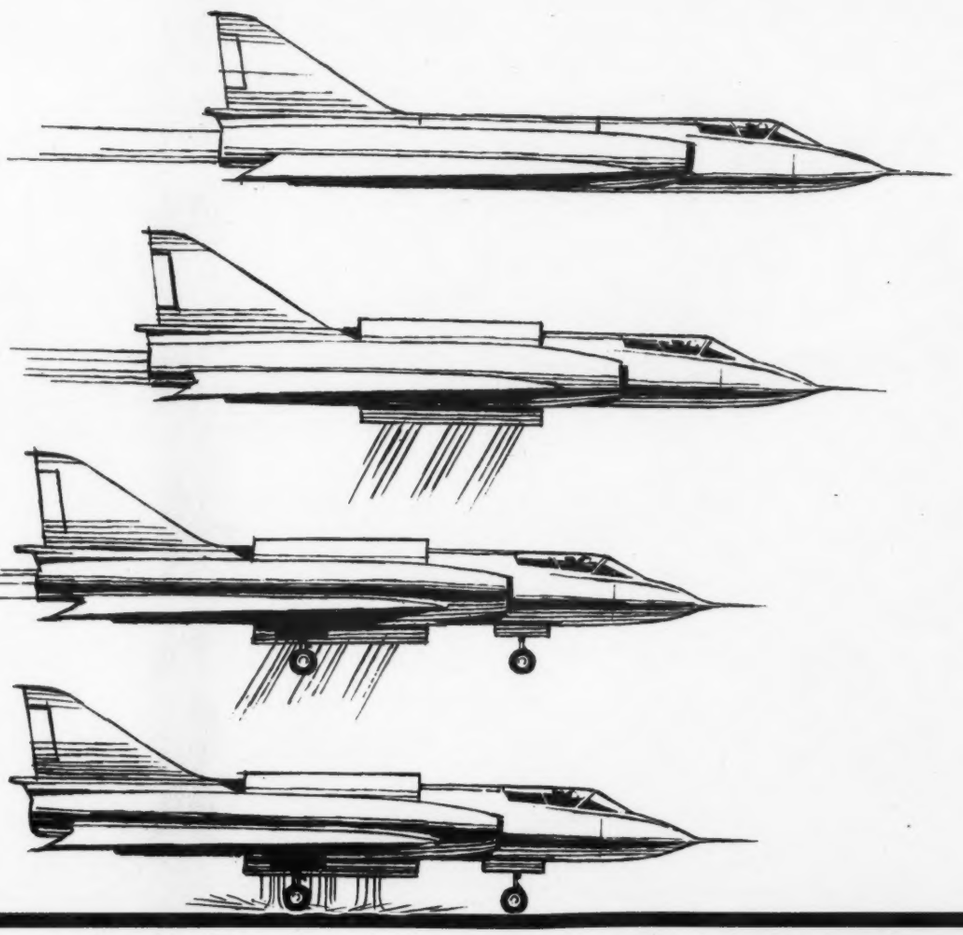

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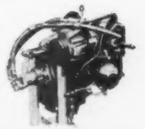

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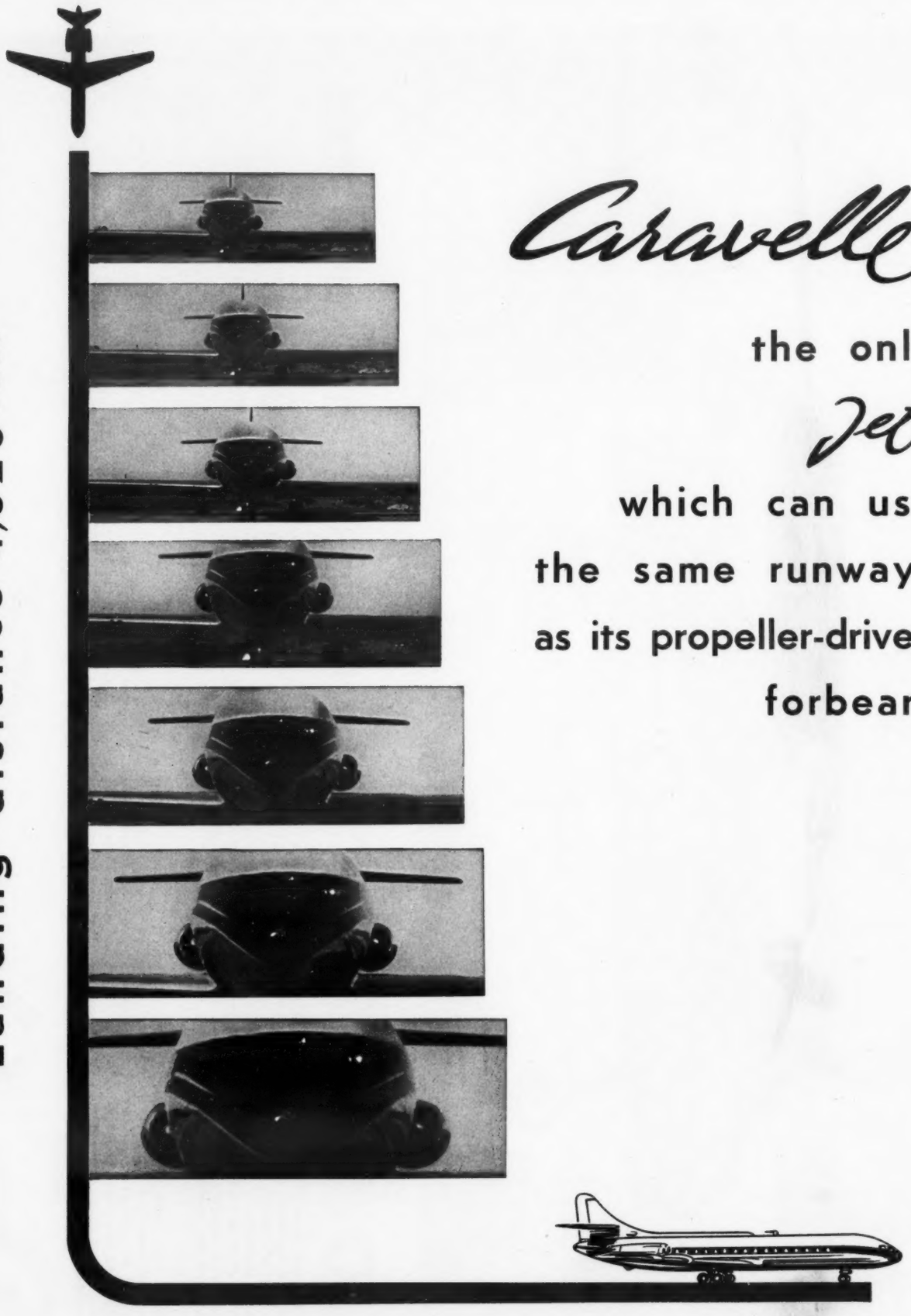

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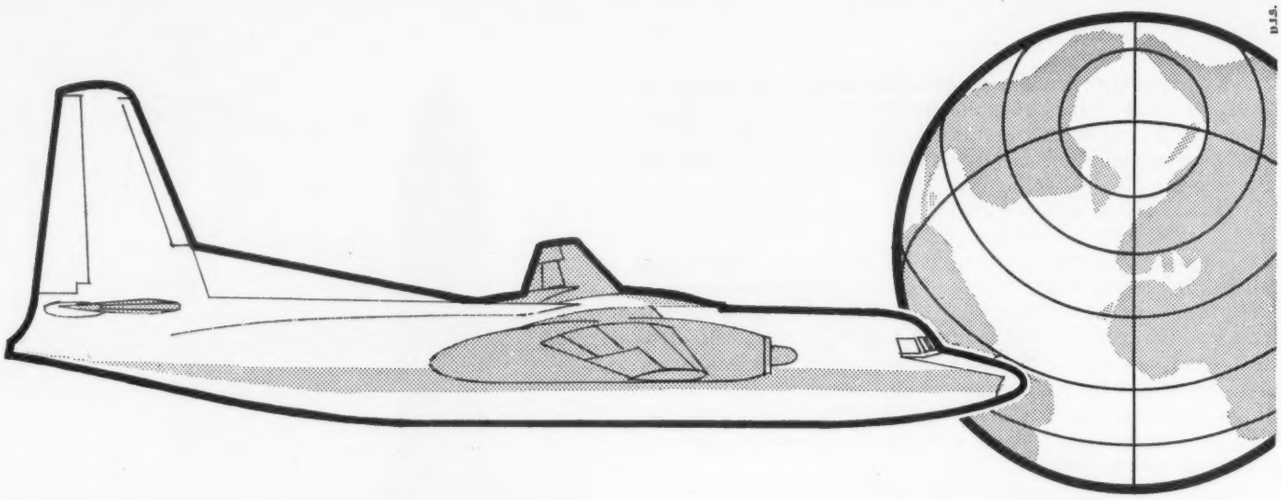

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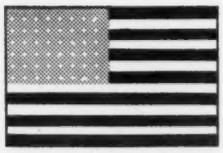
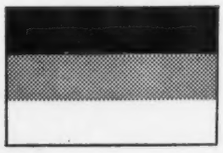


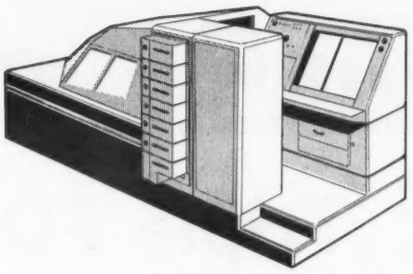
A man should make friends and money, in that order, and use both wisely. Friendships are jewels and there is more art in saving than gaining.

Insan, sirasi ile, dost ve para edinmeli ve ikisinide akillica kullanmalıdır. Dostluk bir ziynettir ve kazanmaktan çok onu devam ettirebilmek bir san'attir.



Der kluge Mann gewinnt erst Freunde und dann Geld. Freundschaften sind wie Perlen, und es ist schöner zu bewahren als zu gewinnen.

Een verstandig mens maakt eerst vrienden en dan geld, en gebruikt beide met overleg. Vriendschappen zijn als juwelen en het is een grotere kunst te sparen dan te verdienen.



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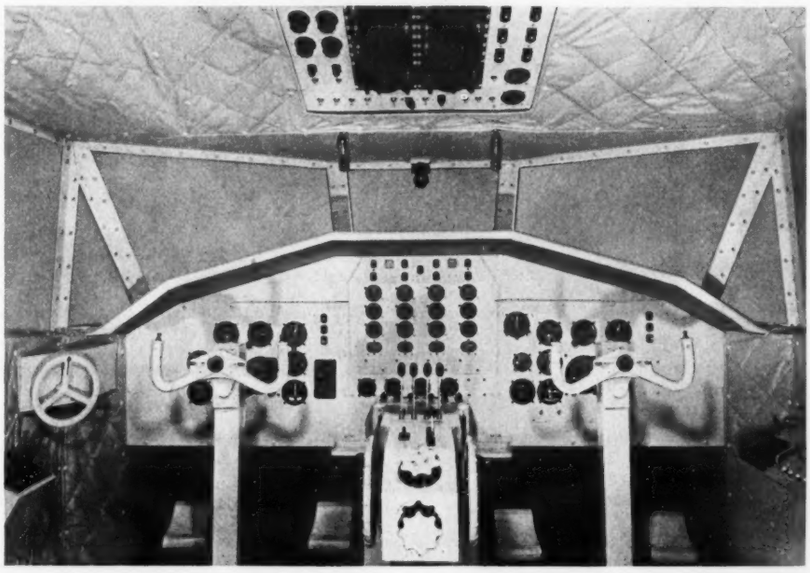

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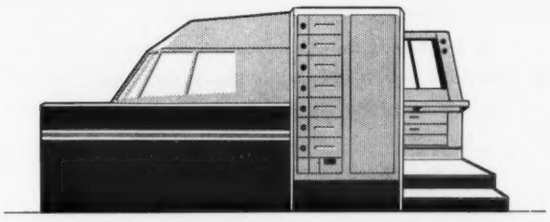

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* Another first by Graviner
* Responds only to temperature rise
* Will not alarm if accidently short circuited
* Uses standard FIREWIRE elements
* World wide availability
* System manufactured in U.S.A. by FENWAL, ASHLAND, MASSACHUSETTS

Fenwal

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GS6

INTERAVIA AIR LETTER reports...*

Air Transportation

IATA North Atlantic traffic for 19 member airlines showed a major increase in capacity, a small increase in passenger volume, and a drop in load factor for the second quarter of 1961:

	First	Economy	2nd quarter total	Percentage over 1960
Seating capacity	176,747	818,242	994,989	+47.3
Revenue passengers	72,277	428,000	500,277	+ 4.5
% seats utilized	40.9	52.3	50.3	—20.6

Cargo and mail volumes recorded on North Atlantic passenger and cargo flights during the quarter were:

	Passenger	Cargo	Total	Variation
Cargo (kg)	7,997,493	6,417,599	14,415,092	+35.2
Mail (kg)	3,255,056	1,344,310	4,599,366	+38.4

●

A US Civil Aeronautics Board Examiner overruled foreign carriers' objections in August, and recommended that public hearings should be held on the thorny question of such carriers being required to submit schedules for approval by CAB and to furnish other traffic data on demand. CAB hearings would affect most carriers operating into the United States.

●

KLM Royal Dutch Airlines reports a net loss of Hfl. 19 million ($5.32m) for second quarter 1961, giving a total loss of Hfl. 37 million ($10.27m) for first half 1961; in large part due to the sharp decline in traffic trends on the North Atlantic run. French independent *Transports Aériens Intercontinentaux (TAI)* reports gross revenues up a healthy 25.7 percent to NF 65,359,389 ($13.1m) for first half 1961. In the United States, international operator *Trans World Airlines* came up with a loss of $11.7 million for first half 1961, against a profit of $4,000 in the first half 1960. TWA's net profit for the month of June was down to $547,000, compared with a record $4.4 million reported for June 1960. Two US domestic operators, *United Air Lines* and *Delta Air Lines*, showed a more favourable position. *United* net earnings totalled $3,359,000 for first half 1961, against a net loss of $1,085,000 in first half 1960, with revenue ton-miles up 25 percent. *Delta* had net income of $4,651,836 for fiscal year ended June 30th, 1961, against $2,839,083 in the previous year.

●

The United States and the Soviet Union reached basic agreement in last month's negotiations for establishment of a direct New York-Moscow air service, and operations may start next spring. CAB has already approved PanAm for the route and technical details are being worked out with the Soviet flag carrier Aeroflot.

●

The UK and the United Arab Republic signed a new bilateral air agreement in August, reinstating full BOAC rights in operation prior to the Suez crisis. BOAC reopened service in 1960 under a temporary permit and currently operates seven roundtrip flights a week through Cairo. BEA does not serve Cairo, which is included on affiliate Cyprus Airways' network.

●

Middle East Airlines, with the support of Lebanese banking and commercial interests, will buy out BOAC'S 48.43 percent holding and gain full independence. Both BOAC management and the British Ministry of Aviation have agreed to the deal. BOAC's shareholding is valued at about £400,000 ($1.1m), but the total amount involved including repayment of BOAC loans is said to be in the order of £3.5 million ($9.8m). MEA has complained of increasing competition from British European Airways in the Middle East and Chairman Sheikh Najib Alamuddin has said that the carrier cannot fight this without affecting relations with BOAC.

●

Swissair's first leased Convair 880-M arrived in Zürich on August 12th and went to Stockholm-Arlanda Airport for crew training preparatory to introduction on the carrier's Far East route on September 10th. A second 880-M was due later in August. Frequency will be three roundtrip flights a week through India and Thailand to Tokyo.

●

SAS Scandinavian Airlines System plans to introduce Convair 990 *Coronados* on the South American route in mid-January 1962, to South Africa in February and on the Southern route to the Far East in March. SAS will introduce twice-weekly DC-8 service on the Southern route to Tokyo on September 28th, supplementing two Polar route flights each week via Anchorage to Tokyo.

●

British European Airways has signed a £2.5 million contract with Standard Telephones & Cables for the first part of a new electronic reservations system. Final total cost will be in the order of £4.5 million. The system will be built round four computers to be installed in BEA's new West London Air Terminal now under construction. Initially serving only reservations desks in the London area, the final installation will be one of the biggest of its type in Europe, linking BEA's whole system by direct landline.

●

The Canadian Air Transport Board opens public hearings September 15th to review regional air service requirements in the western provinces. Recent decisions on eastern routes have supported the policy of strengthening local carriers even at the expense of government-owned Trans-Canada Air Lines. Some western Canadian regional carriers are in urgent need of support, and Pacific Western, the country's third largest operator, is fighting for survival and has an immediate requirement for new equipment. Recent re-financing moves fell through, and the company is now reportedly investigating a possible merger with Transair Ltd., of Winnipeg.

●

American Airlines has confirmed an order for 25 Boeing 727s valued at $131.5 million. Deliveries should commence in 1964.

●

The IATA 1961 AGM opens in Sydney on October 23rd and planning by Australian host carrier Qantas is already well advanced. Indications are that the meeting will be the best attended yet. Bookings already total 420, including delegations from 70 of the 92 member carriers. Conference location will be the new Chevron-Hilton Hotel.

Industry

Messerschmitt is assembling Lockheed F-104G components supplied from the United States at the rate of one aircraft every 14 days. The first European-assembled F-104G flew at Manching on August 10th, and Messerschmitt expects to complete a further fifteen by the end of the year. The West German Air Force's 31st Fighter- Bomber Wing should have 42 *Starfighters* available by July 1962.
In the Netherlands, Fokker is now completing final assembly of the first two of 30 Lockheed F-104Gs to be built from US components, and the first aircraft is scheduled for flight testing in November and delivery in February 1962. The North Group's first production F-104G is scheduled for completion in June 1962.
Canadair has a $847,000 Lockheed contract to manufacture F-104G components for the Italian production programme. First partially-completed wing sections, aft fuselage and tail units will be delivered to Italy in December and continue until July 1962.

●

The US Federal Aviation Agency has outlined an 8-year programme for development of a Mach 3 transport by US aircraft manufacturers with government assistance. Administrator Halaby said the programme calls for R&D of essential components through mid-1963, with construction of the first flight vehicle commencing by January 1964 and initial flight testing scheduled to begin in January 1967. Type certification is anticipated by January 1970. As currently envisaged by FAA, the Pentagon, and NASA, the US supersonic transport will have a gross weight of 400,000 lb, range 4,000 miles, capacity for 100 first- or 150 tourist-class passengers, and a cruising speed of 2,000 m.p.h. at 65,000 ft. Total development cost is estimated at $500 million with a unit production cost of about $15 million. The Kennedy Administration wants to hand over as much of the development effort as possible to US private enterprise and expects to recoup government funds invested in the project.

●

NASA has invited twelve companies to submit prime contractor proposals for the manned lunar *Apollo* spacecraft for lunar orbital flights and lunar landing. Companies to submit bids by October 9th are : Boeing, Chance Vought, General Dynamics, Douglas, General Electric, Goodyear Aircraft, Grumman, Lockheed, Martin, McDonnell, North American, and Republic. A general industry briefing on the *Apollo* spacecraft was held in Washington on July 18th-20th.

●

NASA has given companies (Martin, Lockheed, GD Astronautics, and Douglas) $75,000

* " Interavia Air Letter " is a daily international news digest for specialist circulation, published in English, French (" Courrier Aérien "), and German (" Luftpost "). All rights reserved.

Prototype of the HF-24 single-seat supersonic fighter built by Hindustan Aircraft Ltd. in Bangalore to a design by Professor Kurt Tank. On its scheduled first flight earlier this year the HF-24 did not get off the ground but rapid repair work permitted a successful flight on June 24th. Pilot was Wing-Commander S. Das. Provisionally, the HF-24 prototype is powered by two Bristol Siddeley *Orpheus* BOr. 3 (Mk. 803) of 5,000 lb thrust each, but these will later be replaced by two *Orpheus* BOr. 12s with afterburners. The BOr. 12 has a dry thrust of 6,810 lb or 8,170 lb with afterburning, and the production model HF-24 will have these units.

six-month contracts to study vehicle preliminary design problems involved in flight testing a nuclear rocket engine in an upper stage of the *Saturn* booster. Last August, Martin and Lockheed received $100,000 contracts to study requirements of a nuclear rocket flight test programme and the new contracts will advance the study into the preliminary design phase.

●

Sylvania Electric Products Inc. has received an FAA contract (value unspecified) for provision of 38 Visual Glide Slope Indicator systems for installation at major commercial airports throughout the United States. The system was originally developed by the British Royal Aircraft Establishment and Thorn Electrical Industries Ltd., a Sylvania affiliate.

●

Douglas Aircraft has set up two new divisions and is undertaking a long-term facilities modernization programme. The Missiles and Space Division is headquartered at Santa Monica and the new Aircraft Division at Long Beach.

Ferranti Ltd. has signed a contract with the West German Ministry of Defence for supply of evaluation models of ISIS (Integrated Strike and Interceptor System) Aircraft Fire Control System. Four different versions of ISIS are to be tested in a Fiat G.91, over 300 of which are at present on order for the Federal Air Force. ISIS was developed at Ferranti's Edinburgh laboratories and is a simple, lightweight system for aiming guns, rockets and bombs. Independent of any radar equipment, ISIS employs a gyroscopic method of measuring range to surface targets.

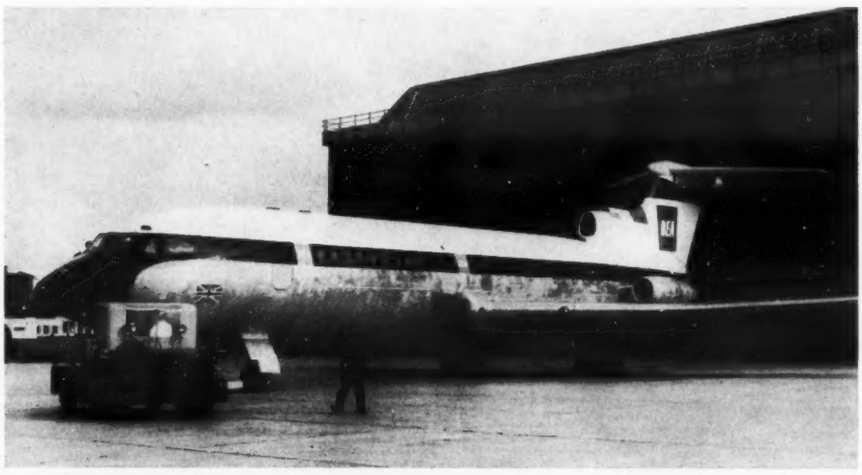
●

D. Napier & Son Ltd. has given Shin Mitsubishi Heavy Industries Reorganized Ltd. of Tokyo licence production rights for the *Spraymat* electrical de-icing system. Japanese production will commence in early 1962.

●

Hawker Siddeley Aviation subsidiaries Sir W. G. Armstrong Whitworth Aircraft and Gloster Aircraft have been merged to form Whitworth Gloster Aircraft. Chairman is Hugh Burroughes (Gloster Chairman). W. S. D. Lockwood (AWA) is Managing Director.

The first of 24 de Havilland DH.121 *Tridents* (three rear-mounted Rolls-Royce *Speys*) for BEA came off the assembly line at de Havilland's Hatfield plant last month. Flight testing is due to start this year, and first deliveries to BEA are scheduled for late-1963. De Havilland also delivered the last of 14 four-jet medium-range *Comet 4Bs* to BEA last month.



The Italian Selenia company has a Swedish military order to supply 14 meteorological radars, with delivery scheduled over the next two years. Value of the contract is reportedly over 500 million lire ($800,000).

●

Siai Marchetti has a pre-production batch of ten four-seat FN 333 *Riviera* amphibious aircraft in hand, with completion scheduled shortly. The company plans a production batch of 200 aircraft, of which 40 are expected to go to the North American market and 160 to European customers. The FN 333 was designed by Nardi and is produced by Siai Marchetti under licence.

Military affairs

The United States' defence appropriations bill for fiscal 1962 has been approved at a peace-time record of $46,662,556,000. Final revised version appropriates $525 million for continued production of B-52 and B-58 bombers and also includes $400 million for stepped-up development of the B-70 bomber. New funding for the Army totals $11,802,312,000; the Navy $14,505,665,000; the Air Force $18,836,534,000; and the Office of the Secretary of Defense $1,310-445,000. Civil defence funds for commencement of work on a multi-billion dollar civilian shelter programme totals $207.6 million.

●

The US Air Force and Navy are being pushed into cooperative purchasing of utility-type transport aircraft (*JetStar*, *Gulfstream* and F-27) by Congress. Joint procurement must be agreed, otherwise funds will be withheld. The Navy says it still has the Grumman and Fairchild models under consideration, and possibly one by Convair. The Air Force has so far refused to consider anything but the jet-powered Lockheed C-140 *JetStar*.

●

The US Navy has funds to start consideration of a new ASW seaplane to succeed the Martin *P5M* which is scheduled for phase-out by 1966. The Navy is expressing concern regarding the US Government lag in aeronautical research as a result of missile and space project competition for funding. The Navy wants an ASW seaplane prototype funded, as well as prototypes for new carrier- and land-based patrol aircraft, carrier-based logistics aircraft, and a heavy logistics helicopter. Navy circles also claim that work is lagging on light air-breathing engines, high thrust engines for vertical risers, and ramjet engines.

●

The US Navy Bureau of Weapons has received industry proposals for development of the ARM (Anti-Radar Missile) system, a small, light, short-range, air-to-surface missile to home in on hostile land- or sea-based radar installations. The Navy has had the project under study for several years.

●

NORAD's Skyshield II exercise, scheduled for October 14th, to test the continental air defence system, will ground commercial and private flights over the entire North American continent for a 12-hour period. Royal Air Force V-bombers will make a simulated strike from UK bases against the US and Canada. The USAF will fly over 6,000 sorties, and missile bases and radar units will also participate.

●

The Italian Air Force's 36th Aerobrigade, two units of which are equipped with 30 *Jupiter* missiles, is being placed under NATO command. Training and technical assistance is being provided by the USAF

(Continued on page 1179)

THE TREND IS TOWARDS AIR PARTNERSHIP

Atlas Copco's contribution to the jet-age — an Air Partner starting a jet airliner at London Airport

Compressed air is power. Little more than one minute is needed for the Atlas Copco "Air Partner" to start the four-engine jet giants of today. Many of the world's principal airlines now use this mobile screw compressor unit – and at Idlewild, London, Orly, Dusseldorf, Hong Kong and other major airports the Air Partner is regarded as an essential part of the ground service facilities.

Wherever you go you will find Atlas Copco equipment at work; portable compressors for a new Middle East pipeline, sprayguns at Jaguar's Coventry works, loaders in the German coalmines or rock drills for Ghana's new Tema Harbour project. The company's air-tools are used to build Sud-Aviation's Caravelle. Philips, Vauxhall and I.C.I. have chosen Atlas Copco compressors for applications where continuous air supplies are vital.

With companies or agents in more than 100 countries, Atlas Copco is the world's largest organisation specializing in this field. Wherever you are, the international Atlas Copco Group will advise you on the applications of compressed air and provide a complete after-sales service.

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Atlas Copco puts compressed air to work for the world

SALES AND SERVICE IN OVER 100 COUNTRIES

MORE POWER FOR FRANCE

The Roselend Valley project in the Savoy Alps involves building two dams and a 476,000kW power station. Atlas Copco equipment has been used almost everywhere on this project – more than 100 rock drills and many thousands of Sandvik Coromant drill steels being employed to drive the main tunnels.

THROUGH THE HEART OF MONT BLANC

When the seven-mile Mont Blanc road tunnel is completed, motorists will have an all-year-round Alpine route between France and Italy. More than half the tunnel is being driven from the Italian side with Atlas Copco rock drills and Sandvik Coromant drill steels. Power is supplied by Atlas Copco compressors.

OIL PROSPECTING IN THE SAHARA

Many of the companies prospecting for oil in the Sahara employ seismic techniques. Atlas Copco supply special equipment for drilling sounding holes. A typical unit is this Atlas Copco truck-mounted compressor – air-cooled for desert work – driving a chain-fed rock drill with Sandvik Coromant drill steels.

IC/1

Saying "useful load"...

and meaning it! That's what the new Aermacchi-Lockheed SANTA MARIA does. This is not just "another" lightplane... it is made to order for the man who needs a *working* airplane—and the proper way for an airplane to work, is to carry a *really* useful load. From propeller spinner to rudder, the " Santa Maria " is all muscle and bone—no delicate gadgets—no chrome ... and there is more than 1,500 lb you can use to carry equipment, fuel, people, cargo. At full range, the payload is still as high as 940 lb—and there is ample fuselage room available for such bulky items as gasoline barrels, vehicles or five passengers. The SANTA MARIA is already in quantity production and FAA certificated.

Practical range (with reserves) 550 miles with a 940 lb payload—take-off distance to 50 ft, 1050 ft—full procedural 500 ft/min climb available at 17,000 ft altitude (with turbo-supercharged engine).

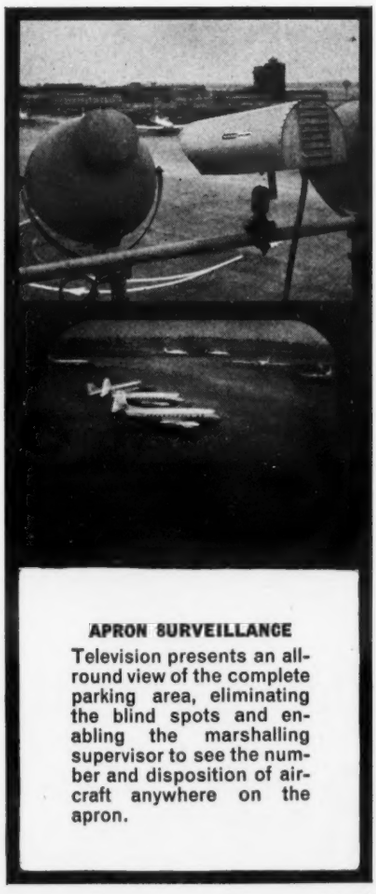
AERMACCHI - LOCKHEED SANTA MARIA

Information on delivery dates from the Sales Manager, Aeronautica Macchi S.p.A., via Sanvito Silvestro 80, Varese, Italy

AIR TRAFFIC CONTROL

Television can present tabulated flight progress information instantaneously wherever it is required in an air traffic control centre.

TAKE A GOOD VIEW



APRON SURVEILLANCE

Television presents an all-round view of the complete parking area, eliminating the blind spots and enabling the marshalling supervisor to see the number and disposition of aircraft anywhere on the apron.

DATA TRANSMISSION FOR AIR TRAFFIC CONTROL

PASSENGER HANDLING INFORMATION

ARRIVAL/DEPARTURE INFORMATION

FLIGHT SCHEDULE INFORMATION

FLIGHT MOVEMENT INFORMATION

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MET. BRIEFING

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APRON SURVEILLANCE

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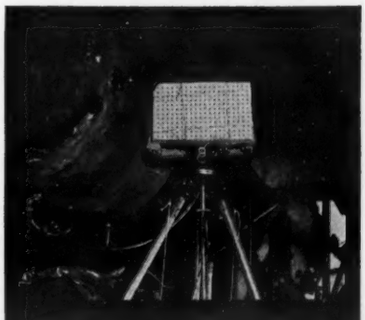


RESEARCH

Observation of after burning in a gas turbine engine at a government research station. This is typical of the many research applications for which television is being used to-day.

a1

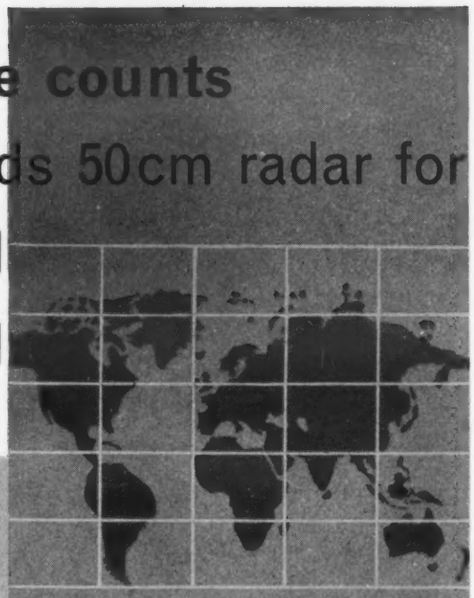
AIRCRAFT
CONSTRUCTION

INDUSTRIE
MECCANICHE AERONAUTICHE MERIDIONALI

AERFER

Wherever performance counts

the trend is towards 50cm radar for airways surveillance and terminal area control



50 CM

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Penetrates thick weather without loss of efficiency.

Crystal controlled MTI for elimination of permanent clutter.

Provides instant readiness after prolonged shut down.

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55

the white heat of speed... the frigid cold of space

STARFIGHTER'S TEMPERATURE EXTREMES REQUIRE PRESTOLITE 350 WIRE.

The Lockheed F-104G scorches along at Mach 2 plus, punches holes in the frigid stratosphere at 100,000 ft. That's why Prestolite 350 silicone-rubber-insulated wire was specified for the "missile with a man in it." Giving top performance from 400°F to –80°F (where it's still flexible), Prestolite 350 Wire has high resistance to flame, abrasion, most missile and aircraft chemicals and lubricants. It is smokeless, won't discolor at maximum cable-operating temperatures, free stripping. It can be printed easily with conventional marking machines, meets Spec. Mil-W-8777 U. S. A. F., is available in sizes 22 through 2/0. Many manufacturers find that Prestolite 350 Wire cuts production costs, too, compared with other high-temperature wires. THE ELECTRIC AUTOLITE COMPANY, Export Sales: Geon International, Great Neck, L. I., U.S.A.

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AD 160 VHF COMMUNICATION
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B.O.A.C. FOR VICKERS VC. 10
B.E.A. FOR D.H. TRIDENT

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND

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INTERCEPTION

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- AUTOMATIC TARGET TRACKING
- COMPUTER CONTROLLED APPROACH
- BLIND OR VISUAL ATTACK

GROUND ATTACK

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- BLIND OR VISUAL ATTACK

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FIAT G91T

Universal trainer for
training from the ab initio
to the advanced
and operational stages

Engine

FIAT 4023-002 Bristol Siddeley Orpheus 80302
(Bristol Siddeley licence)

Static emergency rating (low altitude)	5,000 lb
Maximum continuous static rating (low altitude)	4,200 lb

Dimensions

Length	38.65 ft
Span	28.20 ft
Height	14.60 ft
Wing area	176.74 sq. ft.

Weights

Empty weight	7,275 lb
Takeoff weight	11,770 lb

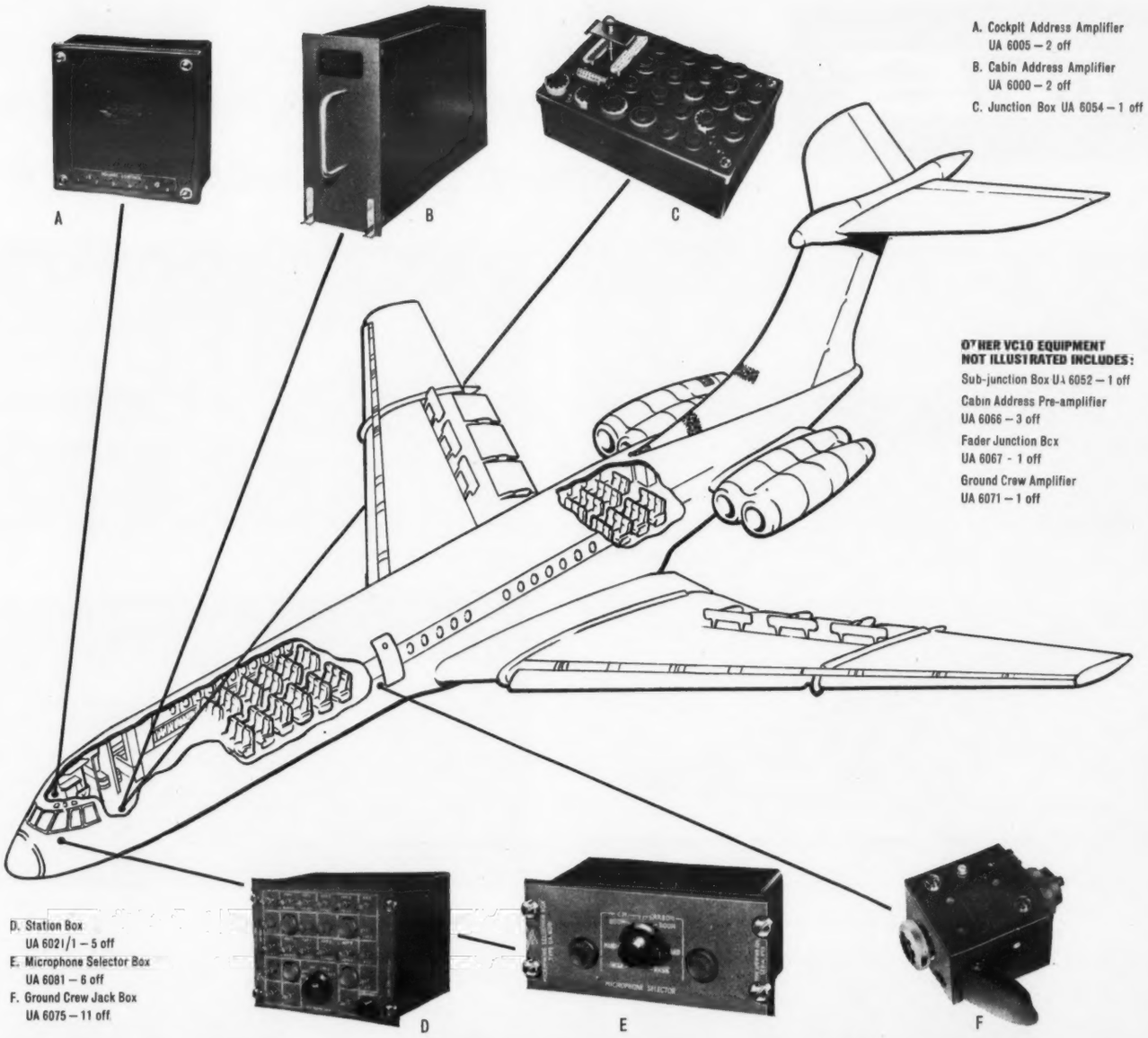
Characteristic ratios

Wing loading at takeoff	66.6 p.s.i.
Weight/thrust ratio at takeoff	2.35

Performance Data

Maximum horizontal speed	Mach 0.92
Stalling speed at 11,000 lb.	124 kts
Time from brake release to:	
13,120 ft	3' 20"
20,240 ft	5' 55"
Service ceiling	42,650 ft
Takeoff run	2,590 ft
Landing run	1,215 ft
Range with external fuel tanks	1,240 n.m.

Fiat - Divisione Aviazione Corso Giovanni Agnelli 200, Turin (Italy)



A. Cockpit Address Amplifier
UA 6005 – 2 off
B. Cabin Address Amplifier
UA 6000 – 2 off
C. Junction Box UA 6054 – 1 off

OTHER VC10 EQUIPMENT NOT ILLUSTRATED INCLUDES:
Sub-junction Box UA 6052 – 1 off
Cabin Address Pre-amplifier
UA 6066 – 3 off
Fader Junction Box
UA 6067 - 1 off
Ground Crew Amplifier
UA 6071 – 1 off

D. Station Box
UA 6021/1 – 5 off
E. Microphone Selector Box
UA 6081 – 6 off
F. Ground Crew Jack Box
UA 6075 – 11 off

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COMMUNICATION CONTROL, INTERCOM & CABIN ADDRESS

...in the VICKERS VC10*

The versatility of Ultra Type UA 60 Communication control and intercom equipment is clearly indicated by the variety of aircraft for which it has been specified, ranging from the Westland Scout helicopter, with seven services, to the Short Bros. and Harland Belfast transport aircraft with thirty-one. And it is equally suitable for American and British radio installations. Audio diffusion amplifiers range from a 2-watt cockpit address type—with integral, but detachable, speaker—to a 60-watt unit developed for use in the Vickers VC10 passenger address system.

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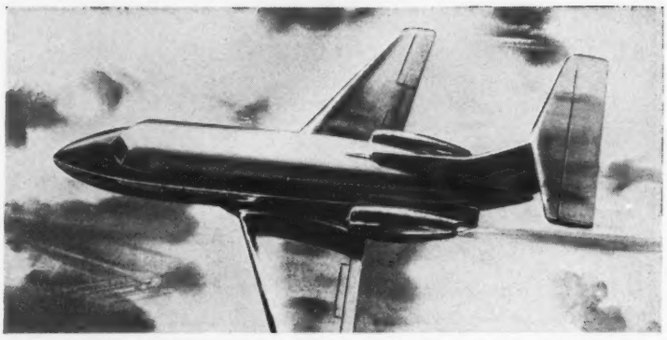
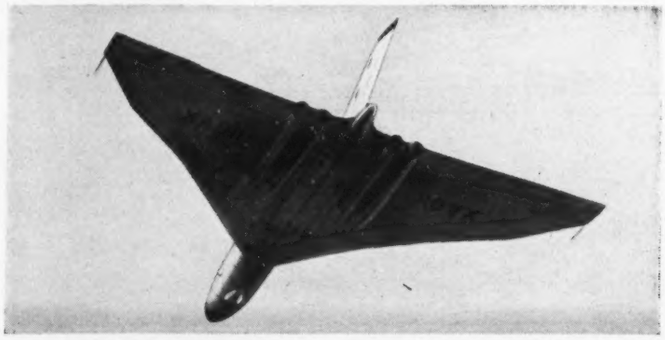


The Bristol Siddeley Viper turbojet has been selected for De Havilland's new 500 mph executive transport—the Jet Dragon.

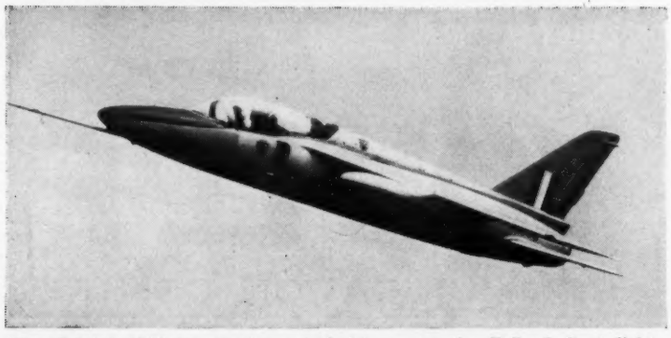
The Bristol Siddeley Proteus turboprop powers the Bristol Britannia airliner in service with 12 airlines and RAF Transport Command.



The Bristol Siddeley Olympus turbojet powers the Avro Vulcan V-bomber, and has been chosen for BAC's new supersonic tactical/support aircraft—the TSR 2.

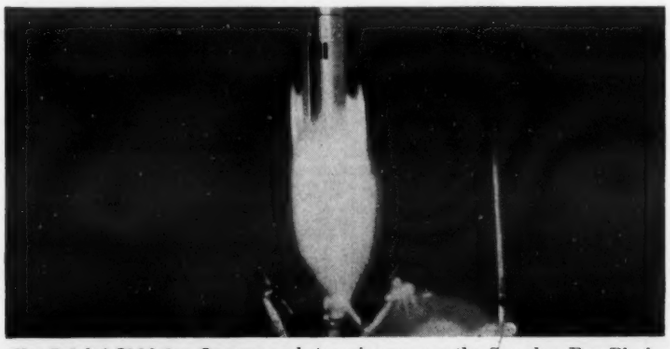
The Bristol Siddeley Sapphire turbojet powers the Handley Page Victor Mk 1 V-bomber which plays a vital role in the RAF's deterrent force.

The Bristol Siddeley Orpheus turbojet powers the NATO standard strike fighter—the Fiat G 91.



The Bristol Siddeley Orpheus turbojet powers the Folland Gnat light fighter—in service with Finland and India.

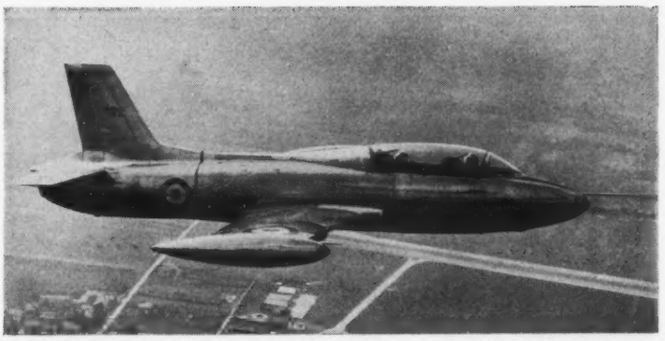
The Bristol Siddeley Stentor rocket engine powers the Avro Blue Steel stand-off bomb carried by the Avro Vulcan bomber.



The Bristol Siddeley Gamma rocket engine powers the Saunders-Roe Black Knight—Britain's highly successful space probe.

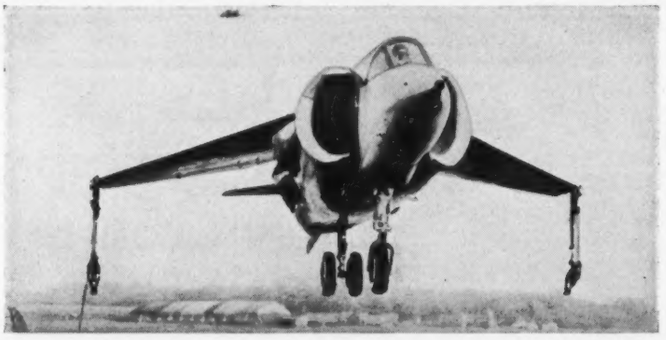
bombers, fighters, missiles,
over the world...

The Bristol Siddeley Viper turbojet powers the Hunting Jet Provost—the RAF's standard basic trainer.



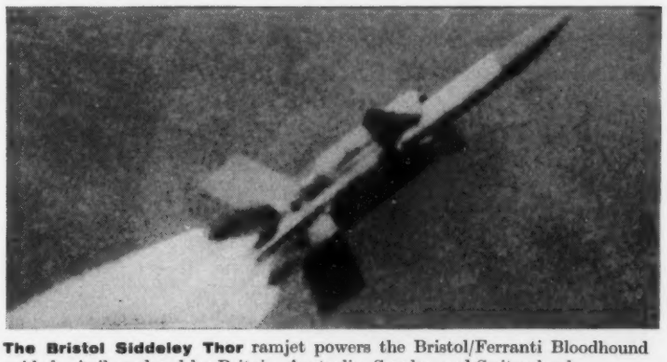
The Bristol Siddeley Viper turbojet powers the Macchi MB 326 jet trainer which caters for both basic and advanced training in the Italian Air Force.

The Bristol Siddeley Sapphire turbojet powers the Gloster Javelin all-weather fighter—a potent weapon in Britain's round-the-clock defence.



The Bristol Siddeley Pegasus turbofan powers the new Hawker P 1127 VTOL strike aircraft.

The Bristol Siddeley Orpheus turbojet powers the HALHF 24 supersonic fighter—first Indian jet aircraft.



The Bristol Siddeley Thor ramjet powers the Bristol/Ferranti Bloodhound guided missile ordered by Britain, Australia, Sweden and Switzerland.

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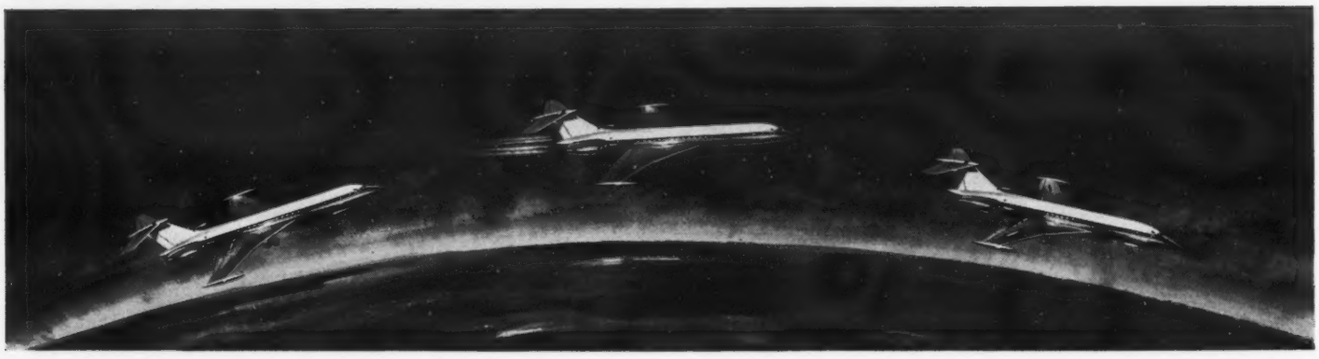

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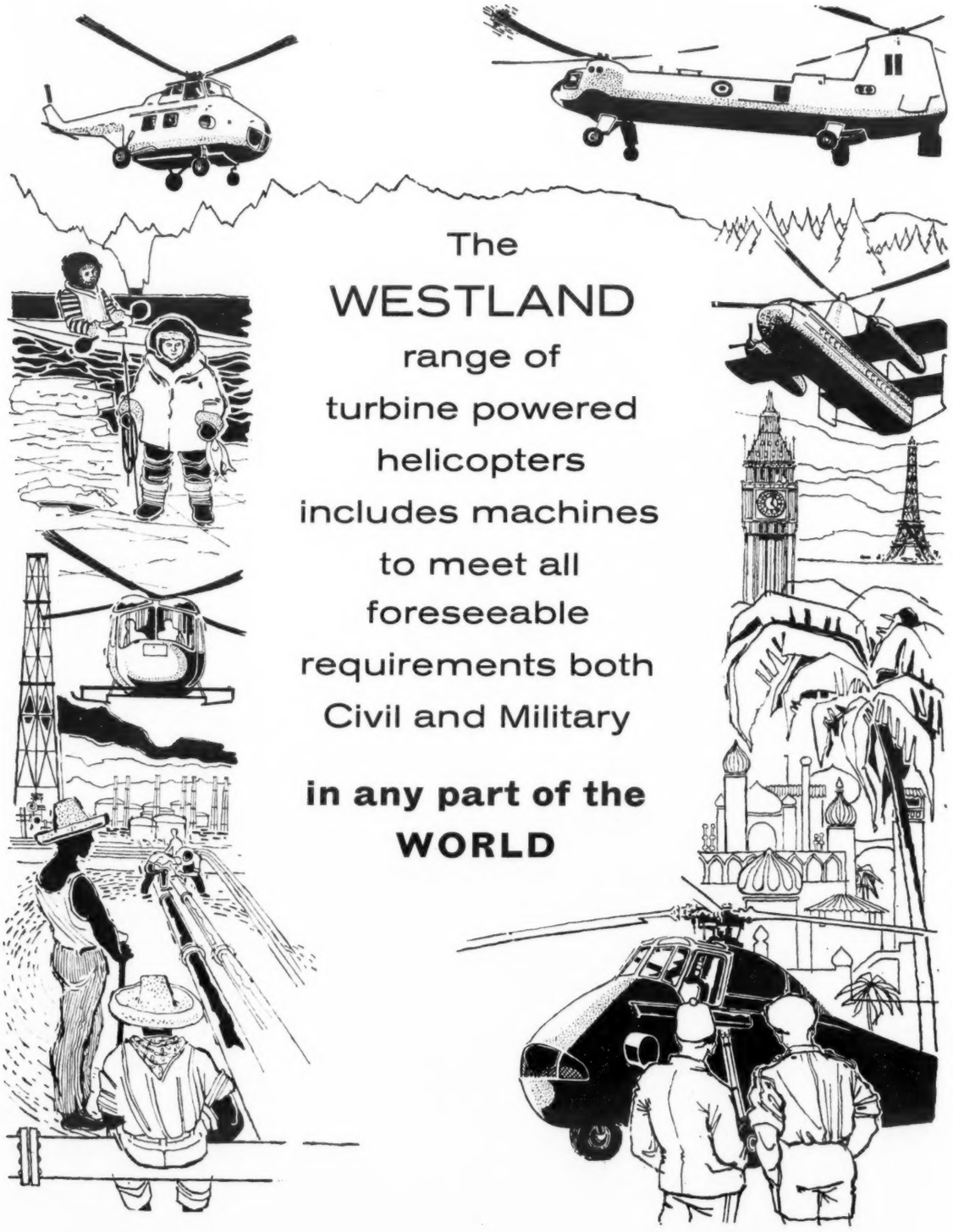

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Seventeen Orbits Round the Earth in 25 Hours

Gherman Titov, second Soviet spaceman.

Major Gherman Titov of the Soviet Air Force.

Mankind, already so accustomed to pilotless space travel that news on this subject has long since disappeared from the newspaper headlines, will soon become just as blasé about the astronauts' ventures and take them merely as a matter of course—especially if launchings of spacemen continue in as rapid succession as hitherto. The first space-flight records * had hardly been entered in the record book of the Fédération Aéronautique Internationale—Gagarin, Shepard, and Grissom had, so to speak, not yet finished their triumphal tours—when these achievements were completely outclassed by a new spaceflight. On August 6th, at 06:00 hours G.M.T, the Soviet spaceship *Vostok 2*, manned by Air Force Major Gherman Stepanovich Titov, took off from Baykonur, 187 miles East of the Sea of Aral. *Vostok 2* was not content with one or two orbits, but carried out seventeen. The Russians' confidence in their own success was shown by the fact that they announced the attempt long before it was concluded. The same fact also goes to prove that the operation was preceded by most thorough testing.

In the words of Tass, "Titov, in the course of the flight, took over the controls of his spaceship." This must surely mean the attitude controls, for a change of the orbit was undertaken only once, namely on re-entry, and this by means of braking rockets. After leaving the spaceship in the ejection seat, Titov landed safely by parachute in the Saratov area, some 450 miles south-east of Moscow, on August 7th at 07.18 hours G.M.T. The spaceship, too, was safely recovered with the aid of parachutes. During its 25-hour flight, the *Vostok 2* covered a total of about 437,000 miles, in other words a distance nearly equal to that of a return journey from the earth to the moon, at an average speed of 17,800 m.p.h. *Vostok 2* is reported to have carried supplies sufficient for ten days, in case required.

The main objects of this second Soviet manned spaceflight were to test the functioning of the equipment during a longer operation, and to determine the effects on the human body, with particular reference to work capability in a state of weightlessness. The pilot confirmed a number of times during the flight that he felt quite well. However, at a Press Conference held in the Moscow Academy of Sciences, he amplified this by the statement that he had felt no appreciable appetite. He had also slept through a radio transmission intended for him, and had at times experienced some discomfort. In the opinion of the Soviet space medicine specialist, Professor Yasdovski, the long period of weightlessness to which Titov had been subjected had resulted in disturbance of the middle ear, which generally leads to nausea, dizziness, and interference with vision. In Titov's case, these symptoms gradually eased off after sleep and disappeared completely when the braking rockets were ignited. This spaceflight provided practically no new knowledge regarding the effects of cosmic radiation, because it took place inside the Van Allen radiation belt (about 187 miles from the earth).

Shorn of its undoubted propaganda value, which the Soviet press exploited to the full, this second manned spaceflight undoubtedly spells tremendous progress in the field of spaceflight technology. Nobody will belittle the achievement of the Soviet engineers, who made it possible for the *Vostok* to land near its destination after 17 orbits. All the same, one only wishes that the Soviet authorities would change over to somewhat more factual reporting and be less prone to publish contradictory information or uninformative, very touched-up photographs of their satellite and spaceship launchings. In the case of carrier rockets, admittedly, secrecy is understandable owing to their military importance. But there are, after all, other aspects of spaceflight, such as medicine, radiation research, theory of gases, and so on, which could be objectively reported without endangering the security of the State.

Perhaps one day it will even be possible for foreign journalists to be present when Soviet spaceships are launched. According to the announcement by Soviet scientists, several more manned spaceflights are in any case scheduled to take place before the 22nd Party Congress in October. Moreover, plans have been made for flights lasting several days, possibly by space vehicles with a number of occupants.

In the absence of technical data . . .

Unlike the Americans with their flood of publicity, the Russians maintain a calculated silence as to the technical details of their space vehicles. In the estimate of American scientists, the takeoff weight of the *Vostok 2* must have exceeded 880,000 lb and takeoff thrust have been at least 1,210,000 lb. It is to be assumed that the carrier vehicle was comparable to that of the *Vostok 1* which—according to information given by the Soviets to the FAI—possessed six rocket motors at the moment of takeoff. For the rest, the following official details are available:

Vostok 2

Weight (less rocket final stage)	10,408 lb
Transmitting frequencies	15.765 Mc/s 19.995 Mc/s 20.006 Mc/s 143.625 Mc/s
Duration of flight	25 hours 18 minutes
Perigee	111 miles
Apogee	161 miles
Inclination	64°56′
Orbital period	88.6 minutes

* Records set up on April 12th, 1961 by Yuri A. Gagarin, USSR, in the space vehicle *Vostok 1*: duration in orbit 1 hour 48 minutes; maximum altitude in orbit 203 miles; maximum weight in orbit at a maximum altitude of 203 miles, 10,417 lb. Those set up on May 5th, 1961 by Alan B. Shepard, USA, in the *Mercury* space vehicle "*Freedom 7*": maximum altitude in ballistic path 115.769 miles; maximum weight in ballistic path 4040.19 lb. Contrary to previous FAI practice, details regarding takeoff and landing places were omitted.

(Continued from page 1162)

group at Wiesbaden in Western Germany. The Turkish Army will also reportedly receive a batch of *Jupiters* in the near future.

●

The Italian Navy has acquired a Hughes Aircraft *Frescan* 3-D radar system from the US Navy and is currently installing equipment on the missile cruiser *Garibaldi*. The *Frescan* system was developed by the US Navy and is currently operational on over 20 US missile cruisers and destroyers. The equipment employs one antenna, transmitter, and receiver to provide simultaneous 3-D pinpoint range, height, and bearing on multiple targets; it features the first electronic stabilization to compensate for ship pitch and roll.

Aircraft and powerplant

The civil version of the Lockheed C-141 has the designation Lockheed 300. Main data for the C-141/Lockheed 300 are: length 146.2 ft; height 39.1 ft; wing span 160.7 ft; wing area 3,228 sq. ft; wing sweep 25°. Maximum takeoff weight is 315,000 lb and maximum payload 93,000 lb. Maximum cruise speed 480 knots, long-range cruise speed 440 knots. Lockheed emphasizes that the civil model 300 is capable of economic operation over relatively short stages up to 500 n.m. and can also transport a payload of over 37 tons on intercontinental routes (e.g. New York-Paris nonstop).

●

The Convair 990 has now been certified for a landing weight of 202,000 lb, an increase of 22,000 lb on the original design weight. General Dynamics/Convair has also announced an increase in maximum takeoff weight.

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INTERNATIONAL MEETINGS AND CONFERENCES

Sept. 1st-2nd: Canadian International Air Show, Toronto

Sept. 1st-8th: International Exhibition of Radio, Television and Electronic Equipment, Amsterdam.

Sept. 3rd-12th: Seventh European Machine Tool Exhibition, Brussels.

Sept. 4th-9th: International Association for Analogue Computation, Belgrade.

Sept. 4th-10th: SBAC Flying Display and Exhibition, Farnborough.

Sept. 4th-14th: RAeS and IAS, Eighth Anglo-American Aeronautical Conference, London.

Sept. 6th-8th: IRE, 1961 Joint Nuclear Instrumentation Symposium. North Caroline State College, Raleigh, N.C.

Sept. 6th-8th: National Symposium on Space Electronics and Telemetry. Albuquerque, N.M.

Sept. 6th-8th: Massachusetts Institute of Technology, International Symposium on the Transmission and Processing of Information.

Sept. 7th-9th: Canadian Business Aircraft Association. Annual Meeting and Static Display, Toronto.

Sept. 10th: International Landing Contest, Saint Nicolas Waes, Belgium.

Sept. 10th-12th: National Aeronautic Association, 1961 National Convention. Westbury, L.I., N.Y.

Sept. 10th-24th: International Technical Fair. Brno.

Sept. 12th-14th: National Association of State Aviation Offi ials. Deauville Hotel, Miami Beach, Fla.

Sept. 13th-17th: Second International Rally, organized by the German Aero Club. Baden-Baden.

Sept. 13-21st: Second World Congress of Flight. Las Vegas, Nev.

Sept. 14th-15th: Institute of Radio Engineers, Conference on Technical-Scientific Communications, Philadephia.

Sept. 14th-25th: National Electronics, Radio and Television Exhibition. Paris.

Sept. 19th: ICAO, Fourth North Atlantic Regional Air Navigation Meeting, Paris.

Sept. 22nd: British Interplanetary Society. "Soviet Space Technology." Northampton College.

Sept. 22nd-Oct. 2nd: International Technical Exhibition. Turin.

Sept. 25th-Oct. 3rd: International Colloquium on Magnetism. Tokyo.

Sept. 26th-28th: National Business Aircraft Association, 14th Annual Meeting. Mayo Hotel, Tulsa, Okla.

Sept. 26th-30th: International Congress of Aerospace Medicine. Paris. CERMA, 5b, Avenue de la Porte de Sèvres, Paris 15e.

Sept. 29th-30th: Society of Experimental Test Pilots 5th Annual Symposium. Beverly Hilton Hotel, Los Angeles, Calif.

Sept. 30th: Institut du Transport Aérien, AFITA, Centro per lo Sviluppo dei Trasporti Aerei, Associazione Italiana di Aerotecnica. 5th Italian-French Aeronautical Conference, Rome.

Oct. 2nd-4th: Institute of Radio Engineers, 5th Biennial Canadian Electronics Conference on "Progress through Electronics." Toronto.

Oct. 2nd-6th: IAF, 12th International Astronautical Congress. Washington.

Oct. 2nd-4th: IRE, 7th National Communications Symposium. Utica, N.Y.

Oct. 3rd-5th: American Association of Airport Executives, 1961 National Airport Conference. Norman, Okla.

Oct. 4th-6th: American Society of Photogrammetry, Semi-Annual Convention. Biltmore Hotel, Now York.

Wall Street and the Berlin Crisis

by Scott Hershey

President Kennedy called for heavy defense spending to back up his pledge of "no retreat" on Berlin, and the stock market, more sensitive than ever to world news, responded by soaring to all-time highs.

Ever since it became clear that the United States would meet new Soviet threats over Berlin with a major build-up, Wall Street analysts have been telling investors that stock prices would respond in this way. Until the Kennedy speech to the nation, the market had been in the doldrums, with the bulls holding hope for a summer rally. It came... borne on the wings of business recovery and some apprehension of impending inflation.

Naturally, the so-called defense stocks were avidly sought by investors rushing into the market, and the steadily rising prices reflected their enthusiasm. Missile and aircraft stocks were among the most popular items.

The long-term effect on the market of the Soviet's spectacular earth-orbiting spaceship remains to be seen. However, since Congress has indicated willingness to go along with almost any expenditures to keep pace, or catch up, in the space race, the effect may be nominal.

While the Soviet achievement has drawn attention away from other areas of the cold war, tension over Berlin continues to increase. Most market observers feel that missile-aircraft issues should have periods of popularity from time to time and that they bear watching by discriminating investors.

Some of the better performers in the missile-aircraft group are Douglas, with a new B-47 contract, and Boeing, after showing a first-half profit, which increased the return to $2.03 a share from last year's $1.29. Others finding favor in the new market were Lockheed, Lear, Ryan, Grumman, Bendix, Northrop, Aerojet-General and McDonnel. Martin, with its June quarterly earnings including profit from sale of investments totalling $1.37 per share, was also in demand. One of the most active in this group was the Avco missile concern.

North American Aviation attracted many investors, following a satisfactory financial report, at which time the company's President, John Leland Atwood, commented that it was time somebody coined a new word or name for his industry. He noted that diverse products would give his company sales of more than $1.2 billion this year, and added that what once was called the aircraft industry "has clearly become something else that almost defies classification." The "aerospace" industry, which has been adopted as a common substitute, he rejected. He said it did not cover North American's work on hydrofoils, atomic reactors, and the conversion of salt water.

The name does not cover Martin's activities either, the firm having just completed consolidation negotiations with the American-Marietta Company. Such consolidation indicates the way of the aircraft industry. Martin, of course, no longer produces airplanes, but is a leading concern in missiles, aerospace, electronic, and nucleonic activities. American-Marietta produces paints, industrial finishings, household cleaning products, synthetic resins and adhesives, chemicals, cement, printing ink, and a wide range of building and construction materials. It does not take an old-timer to remember when Martin was a leading aircraft manufacturer.

With airplane makers in many diversified activities, such as rocketry, astronautics, and electronics, and, in some cases, no longer making airplanes at all, it appears that a new name for the industry is, as Mr. Atwood suggested, indeed called for.

* * *

In the meantime, the professional managers of the investment companies are being watched for their reaction to the market both before and after the break-through to new highs. The 160 open-end investment company members of the National Association of Investment Companies have combined assets in excess of $20 billion, and their shareholder accounts at mid-year topped five million. Their shareholders are largely in the market for the long-term, and little concerned with market fluctuations.

The mid-year reports indicate that aircrafts were favored and, to a lesser degree, airlines. The investment companies went in a big way for Lockheed, Boeing, Northrop, North American, Grumman, Martin, General Dynamics, although opinion was not by any means unanimous.

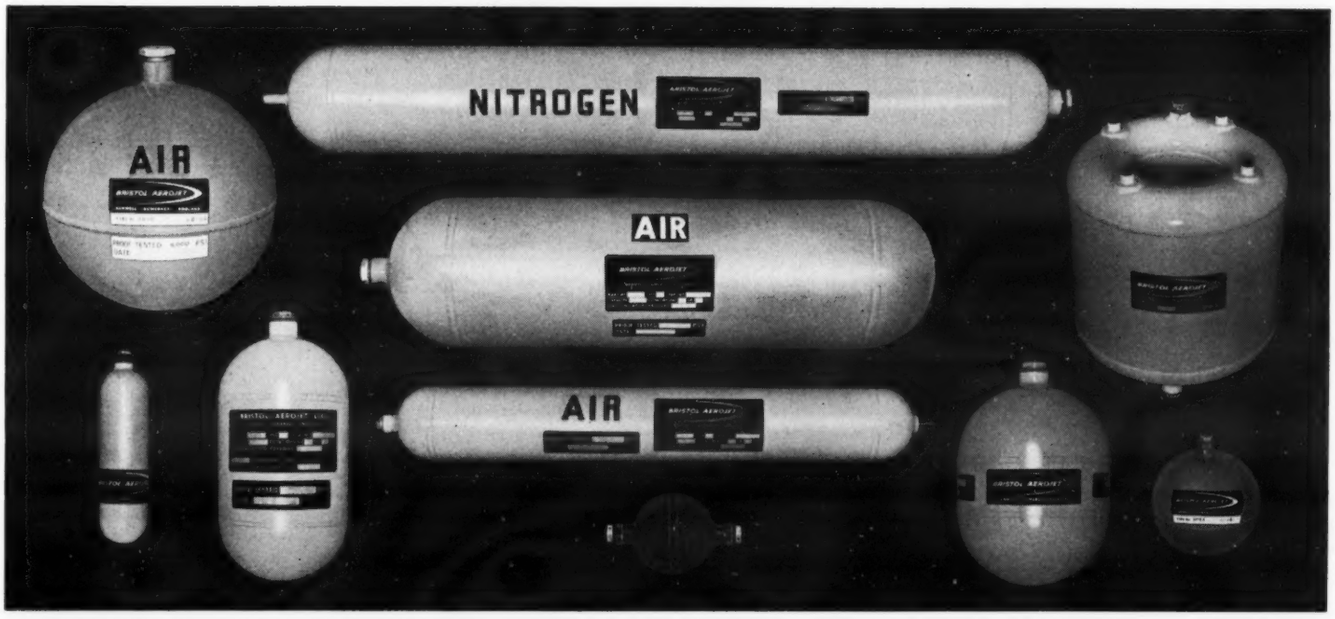
Among the airlines, at least six investment companies found American Airlines to their liking, and none of the companies reporting sold this share. Pan American found favor with several investment companies, as did United Air Lines, whose integration with Capital has been accomplished with comparative smoothness since United absorbed Capital's routes, most of Capital's personnel, as well as, of course, Capital's obligations. There were some sales of shares by investment companies of Northeast (which has been having its troubles), Delta, and Eastern. The prices of these stocks, however, held up fairly well. TWA, which did not figure in these transactions and which last year had much difficulty in arranging new finance for the purchase of equipment, is expected soon to complete arrangements for borrowing $140,000,000 from a banking-insurance group headed by the Irving Trust Company and the Equitable Life Assurance Society. This new borrowing is in addition to the $165,000,000 borrowed by this airline last year, after Howard Hughes trusteed his 78 percent ownership of TWA. It is understood that, under the newest loan arrangement, provision will be made for TWA to borrow at least $100,000,000 more for the purchase of new, shorter-range jet planes.

* * *

Earnings reported for the second quarter of this year and the equivalent quarter of 1960 indicate that airlines are up about 8.7 percent, and eight aircraft manufacturers showed second quarter earnings of $15,438,000, as compared with $10,586,000 a year ago, the change being a plus of no less than 45.8 percent.

Many of the big gainers on the Big Board were, interestingly enough, the stocks of companies unconnected with defense, and thus impervious to increased defense expenditure, except in a general way. Thus, it appears, the market offers almost anything the selective investor might want.

PERFORMANCE PAYLOAD PROFITS UP



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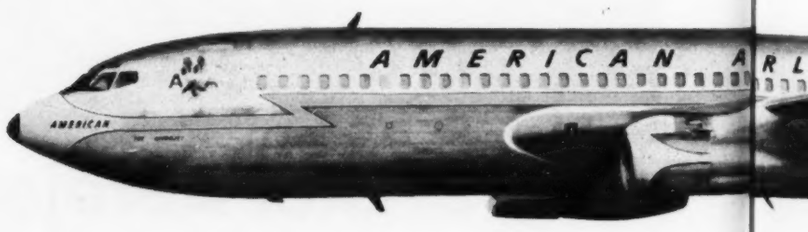

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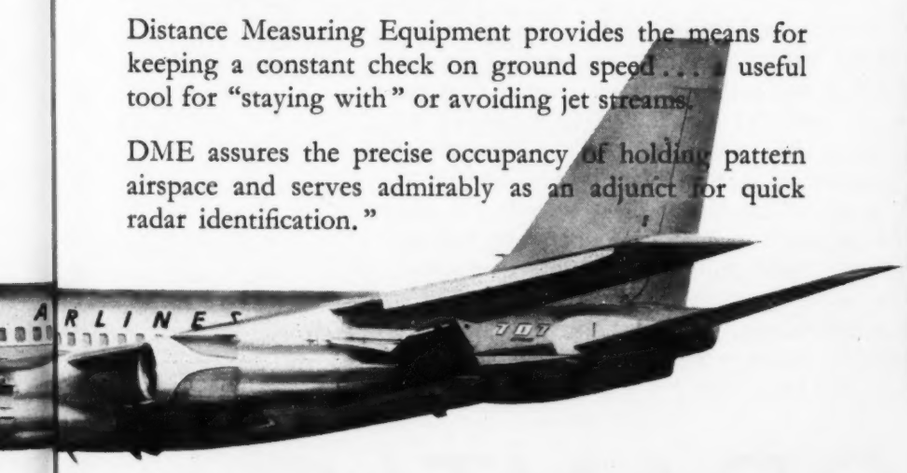

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193-mph Speed Record Set by Sikorsky HSS-2 To Smash USSR Mark

Washington, D.C.—A new helicopter world speed record of 192.9 mph was recently established by a U.S. Navy Sikorsky HSS-2 turbocopter over a three-kilometer straight-course.

Fastest previous speed was 167.09 mph, flown by a Russian Mil-6 over a closed 100-kilometer course in late 1959. The Sikorsky HSS-2 recently reclaimed this record from the Soviet Union by flying a similar course at 174.9 mph.

The HSS-2, a key weapon in U.S. antisubmarine warfare defense, is one of several U.S.-built military and commercial turbocopters powered by the 1250 shp General Electric T58 turboshaft engine. Other military T58-powered 'copters are the Kaman HU2K, which will be used for Navy utility, search, and rescue missions, and the Boeing-Vertol HRB-1, recently selected as assault transport by the U.S. Marine Corps.

Commercial version of the record-holding HSS-2, the Sikorsky S-61, enters commercial service with Los Angeles Airways and Chicago Airways this year. A civil version of the HRB-1, designated the Boeing-Vertol 107, will also enter commercial airline service this year on routes of New York Airways. These twin-T58-powered turbocopters carry 25-28 passengers, and are expected to help reduce seat-mile costs substantially below those possible with present piston-powered helicopters.

The smaller Sikorsky S-62, which is powered by a single derated G E T58 engine, is currently handling passenger service in Los Angeles and San Francisco. The S-62 was the first U.S. turbocopter to be certificated for commercial operation. Its G E engine was the first U.S. helicopter gas turbine powerplant certificated by the FAA for commercial operations.

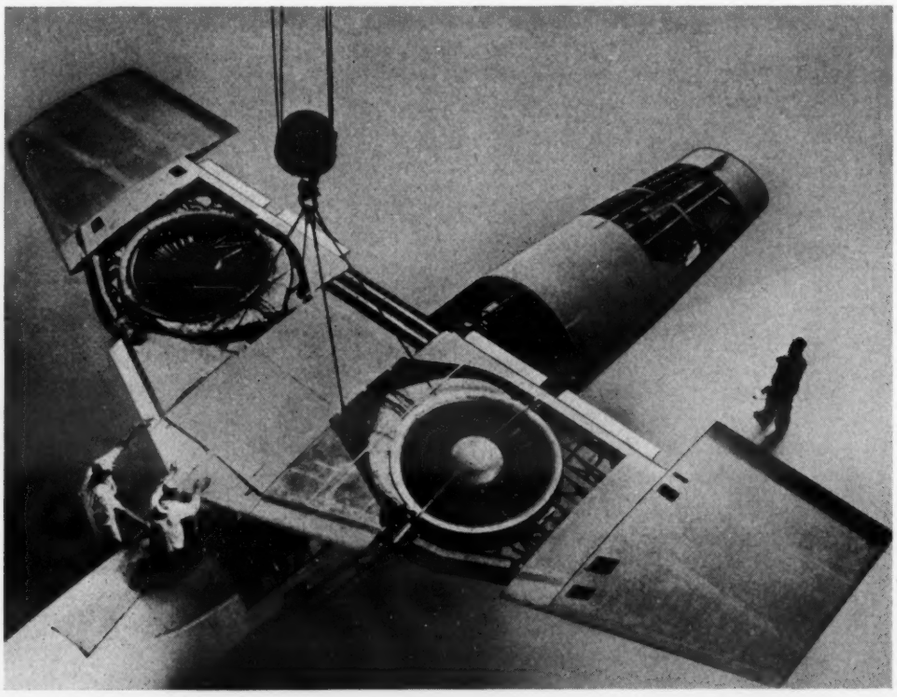
The 1050 hp T58 has also been selected to power the Kaman K-16 flying boat, and the four-prop Fairchild M224, both of which are STOL aircraft under consideration by the U.S. government.

T58 powered Sikorsky HSS-2 turbocopter set a world speed record of 192.9 mph.

FIRST RUN-UP OF G E T64 ENGINES in the de Havilland DHC-4 Caribou occurred at de Havilland's Downsview, Ontario, plant recently.

Tie-down tests of the instrumented STOL aircraft will lead to flight testing of the General Electric turboprop engines later this summer. The program is being conducted by G.E.'s Small Aircraft Engine Department and de Havilland Aircraft of Canada under U.S. Navy sponsorship and with cooperation of the Canadian Government.

G.E.'s T64 turboprop version, which develops 2850 equivalent shaft horsepower and has a corresponding specific fuel consumption of 0.49, is currently under consideration for several advanced, medium-range transports. T64 turboshaft configurations have been proposed for a variety of VTOL aircraft.



FAN-IN-WING MODEL READIED FOR TESTS – Next test phase for the General Electric lift fan will be in a fan-in-wing configuration. Testing will be conducted in the NASA, Ames, California, 40′×80′ wind-tunnel. The two-fan, two-J85 engine powered wind-tunnel model will provide aerodynamic and mechanical design data for a subsequent flight research program.
Tests will begin in September, 1961, in this continuing V/STOL propulsion system research effort under Army (TRECOM) contract.

NEWS

A report about progress in research and products from the Flight Propulsion Division of the General Electric Company

J79 Engine: Power for Eighteen U.S.-held Flight Records

Cincinnati, O. — U.S. aircraft powered by General Electric J79 engines have captured nearly one-half of world aviation's official jet aircraft speed, altitude, and time-to-climb records during the past two-and-a-half years.

Of 42 internationally recognized marks in these three categories, 20 are currently held by U.S. military aircraft. All but two of the U.S. record flights were flown by J79-powered jets—Convair's B-58 Hustler, the Lockheed F-104 Starfighter, the McDonnell F4H Phantom II, and North American's A3J Vigilante.

Half of these record-shattering performances are credited to the Lockheed Starfighter, which holds the official altitude record of 103,395.5 feet and all eight time-to-climb records from 3000 to 30,000 metres.

Convair's B-58 Hustler, demonstrating its prowess as the nation's first supersonic bomber, has rewritten six world speed records since the start of 1961. In January, the Mach 2 bomber carried a 2000-kilogram payload over a 2000-kilometer closed-course, averaging 1061.8 miles per hour. The flight set new records for three different payload classes. A few days later another Hustler clinched the 1000-kilometer-course record for the same three payload classes with an average speed of 1284.73 mph.

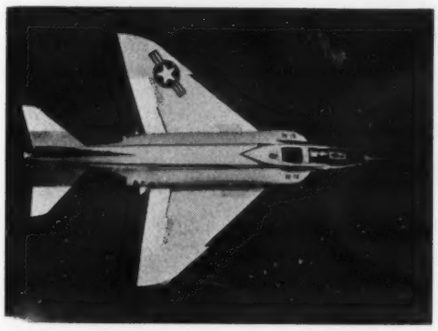
The Hustler received the 1961 Thompson Trophy for this feat. Later, in May, another Hustler claimed permanent possession of the Blériot Trophy—after sustaining a speed of 1302 mph for more than 30 minutes over a closed course.

Another U.S. Mach 2 aircraft, North American's A3J Vigilante, took its place in international aviation annals during 1960 when it smashed the Russian-held 1000 kilogram-payload altitude record by nearly 25,000 feet. The J79-powered Vigilante's record still holds at 91,450.8 feet.

Fourth member of the J79-powered record-breaking team, the McDonnell F4H Phantom II, broke two Russian-held records in the fall of 1960. The Mach 2 Navy fighter streaked over a 500-kilometer closed-course at 1216.78 mph, and a few weeks later logged 1390.21 mph over a 100-km closed-course.

Most recent proof of the Phantom II's prowess came in May of this year when the J79-powered fighter captured the Bendix Trophy by slashing 20 minutes from the previous trans-American flight record.

Of these four J79-powered jets, two—the F-104 and the B-58—are currently in operational duty. The F4H Phantom II and A3J Vigilante are expected to enter fleet operations with the U.S. Navy in the near future.



Record-holding McDonnell F4H will soon become operational with the fleet.

The A3J's 91,451-ft. altitude mark smashed a Russian record by nearly 25,000 feet.

For a free brochure featuring full-color illustrations of these record-setting aircraft — F4H, A3J, F-104, B-58, and 880 — just clip and mail the coupon below.

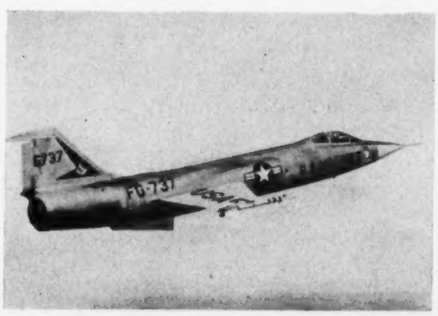
Convair 880 Powered to Three Records by CJ-805 Engines

Powered by G.-E.'s CJ-805-3 turbojets—commercial version of the J79—the Convair 880 jetliner has established three major domestic speed records since entering service in May, 1960.

In its first month of scheduled service with Delta Air Lines, the Convair jet raced 2359 miles from San Diego to Miami in three hours and 31 minutes.

A few months later 880's destined for Northeast Airlines cut San Diego to Boston flight time to four hours and 10 minutes.

Most recently, a TWA 880 set a new commercial speed record when it linked San Francisco and Chicago in two hours and 57 minutes—38 minutes under the scheduled flying time.



Lockheed's F-104 holds more world flight records than any other American aircraft.

USAF's record-setting Convair Hustler is the world's first operational Mach 2 bomber.

Convair 880: 3 records the first year.

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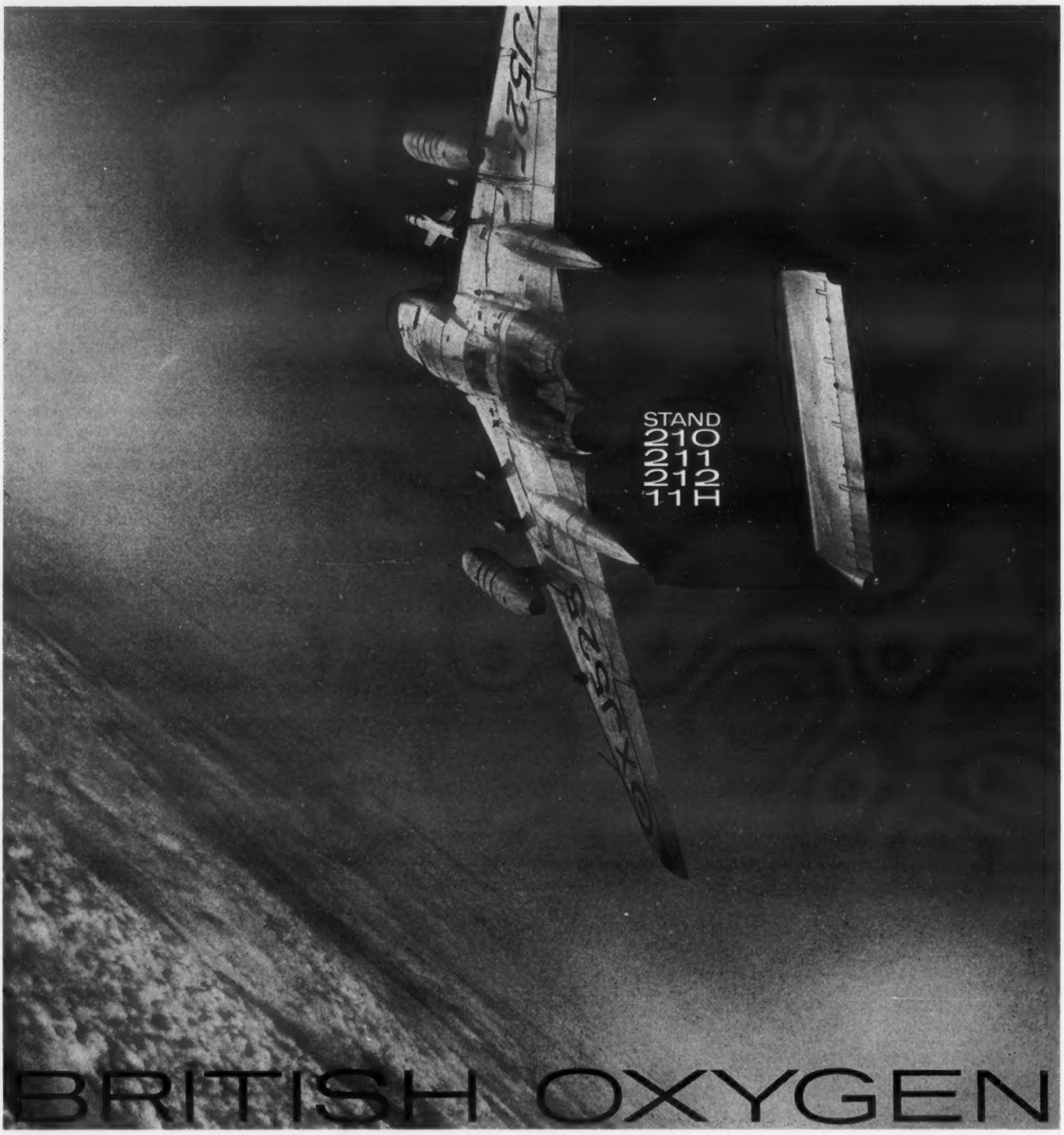

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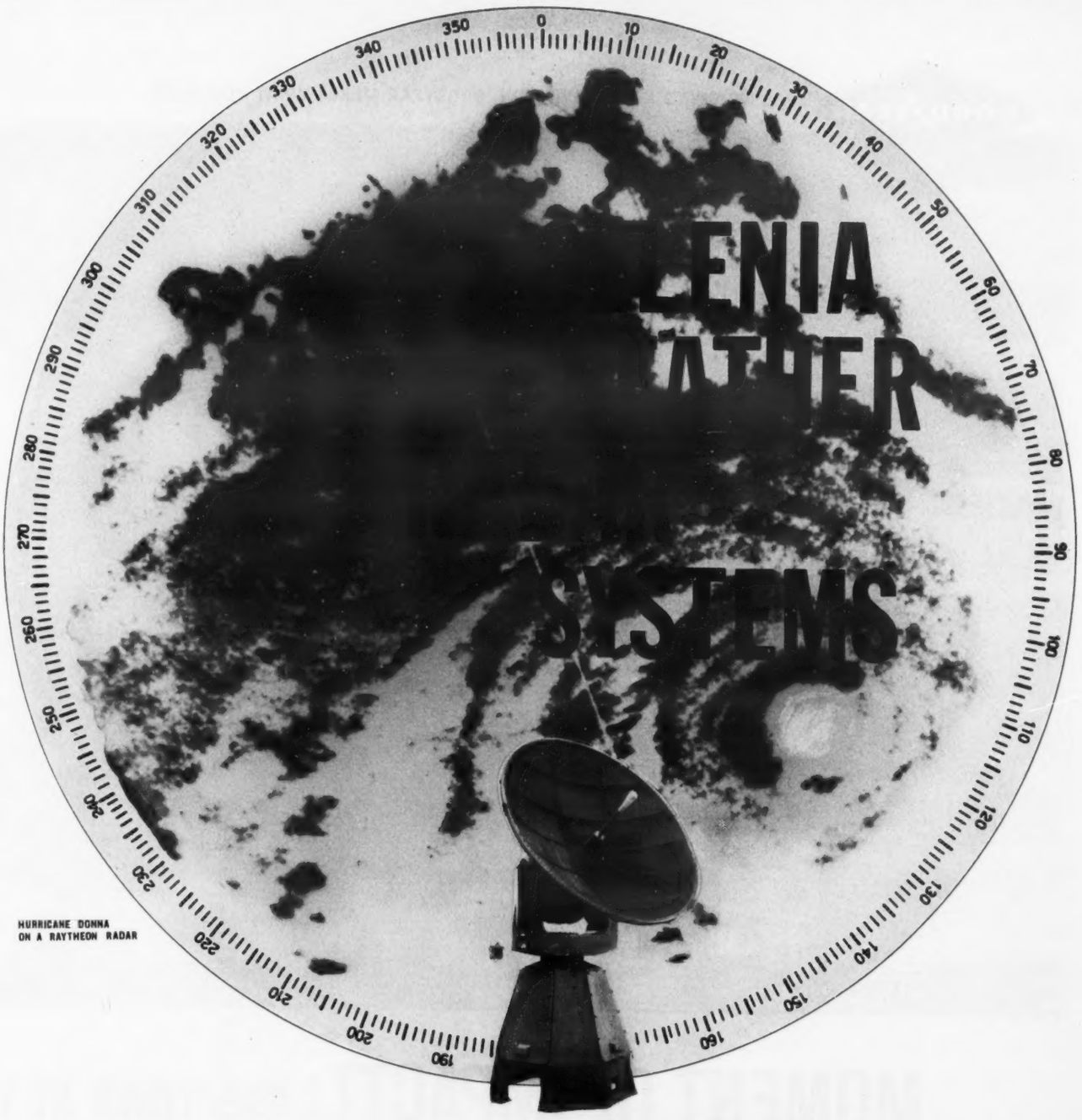

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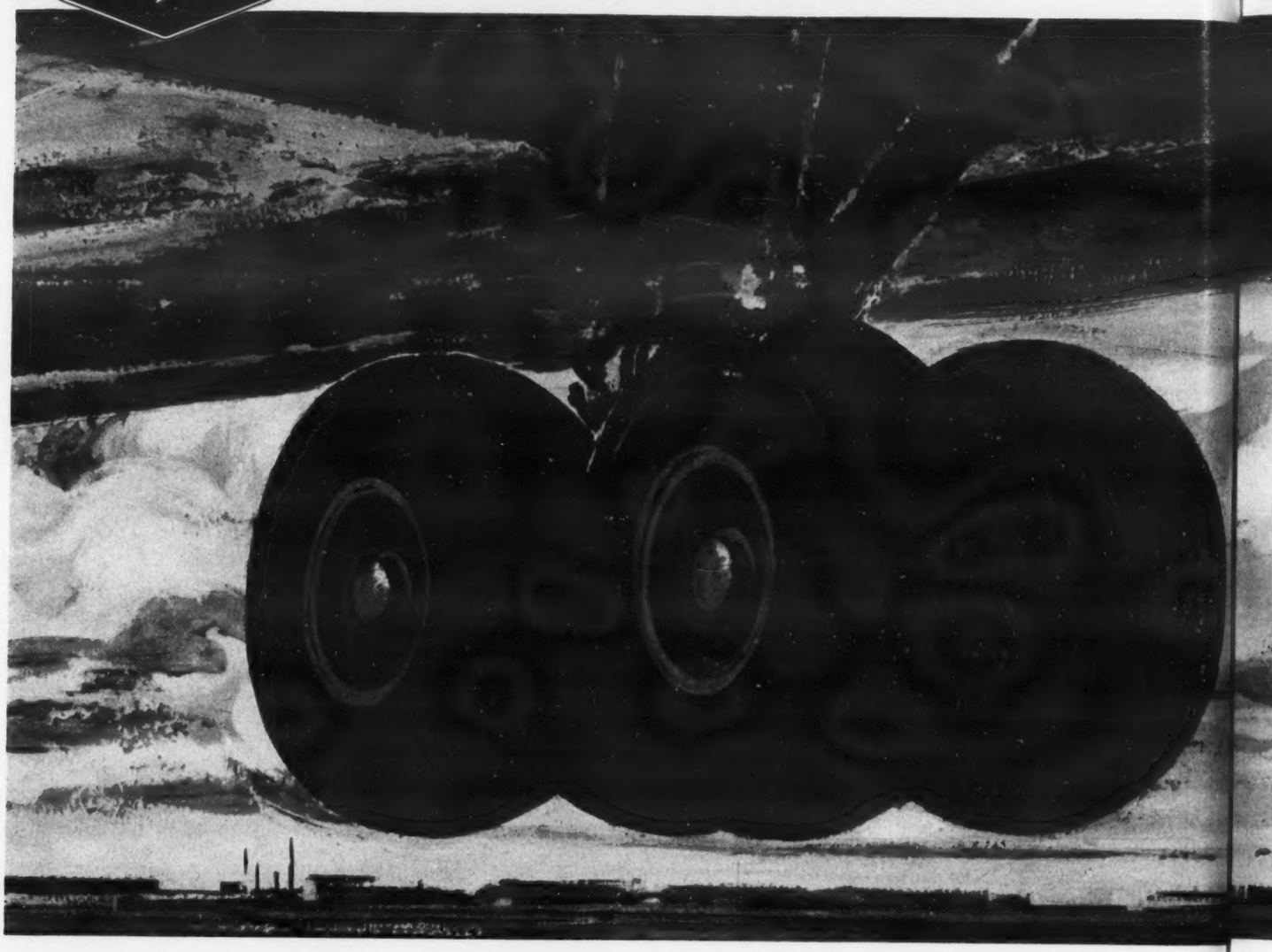

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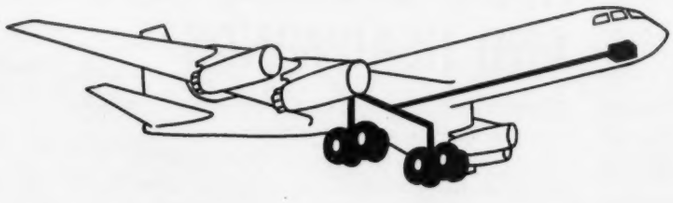
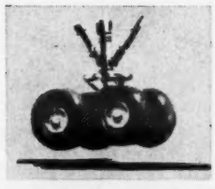
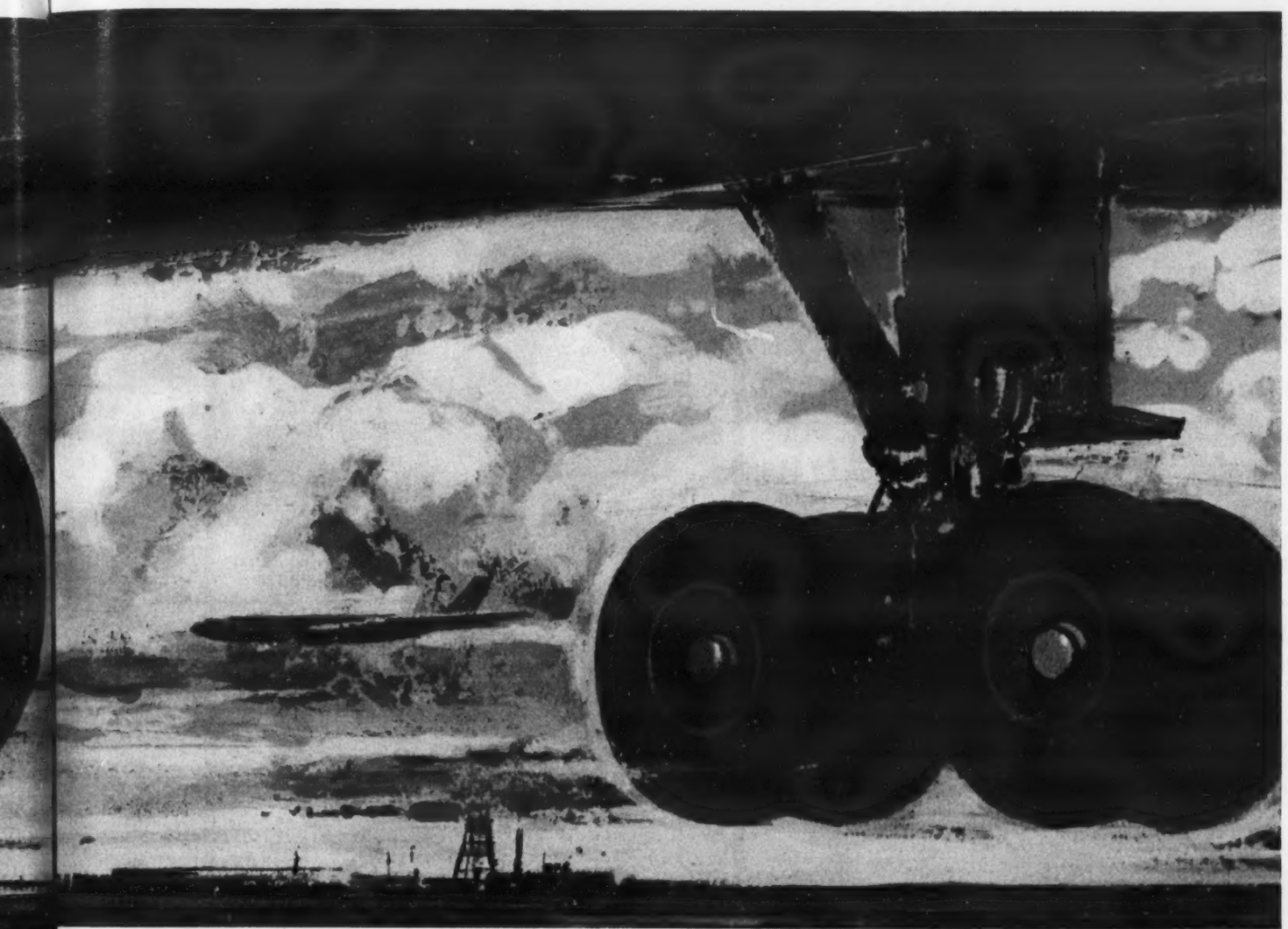


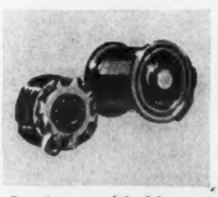


WANTED: A tire to accelerate from zero to 200 m.p.h. in seconds – 155 tons of airplane entrusted to its tires until airborne. Tire must also cushion the landing impact on to a rock-hard runway and bring the tremendous weight to a smooth, safe halt.

The tire that got the job was no beginner. It was developed by Goodyear for U.S. jet fighters. Its new, fabric-reinforced tread withstands the stresses of high-speed take-offs and landings. Now giant jets the world over depend on Goodyear aircraft tires to take the great mechanical strains of modern flying.



MILES PER HOUR!



WANTED: Wheels and brakes to carry and stop the equivalent load of several trailer trucks moving faster than any sports car. No margin for errors—efficiency at all times an absolute must.

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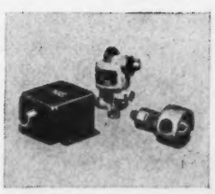

WANTED: A brake control device that thinks and acts with the speed of lightning. Device must sense skid tendencies—and at speeds up to 275 m.p.h. It must react instantly to prevent wheel lock-up. With anti-skid, the brake can take advantage of the full tire coefficient and produce the shortest possible stopping distance.

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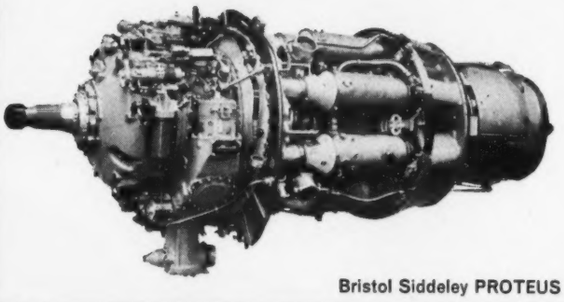

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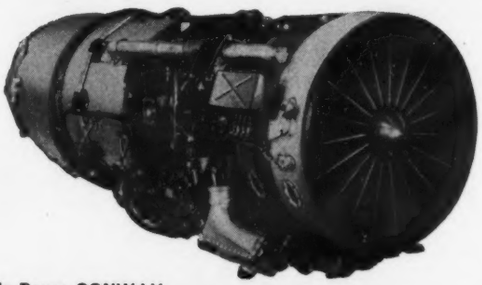

Rolls-Royce CONVAY

Photographs by courtesy of Bristol Siddeley Engines Ltd., Rolls-Royce Ltd., & B.O.A.C.

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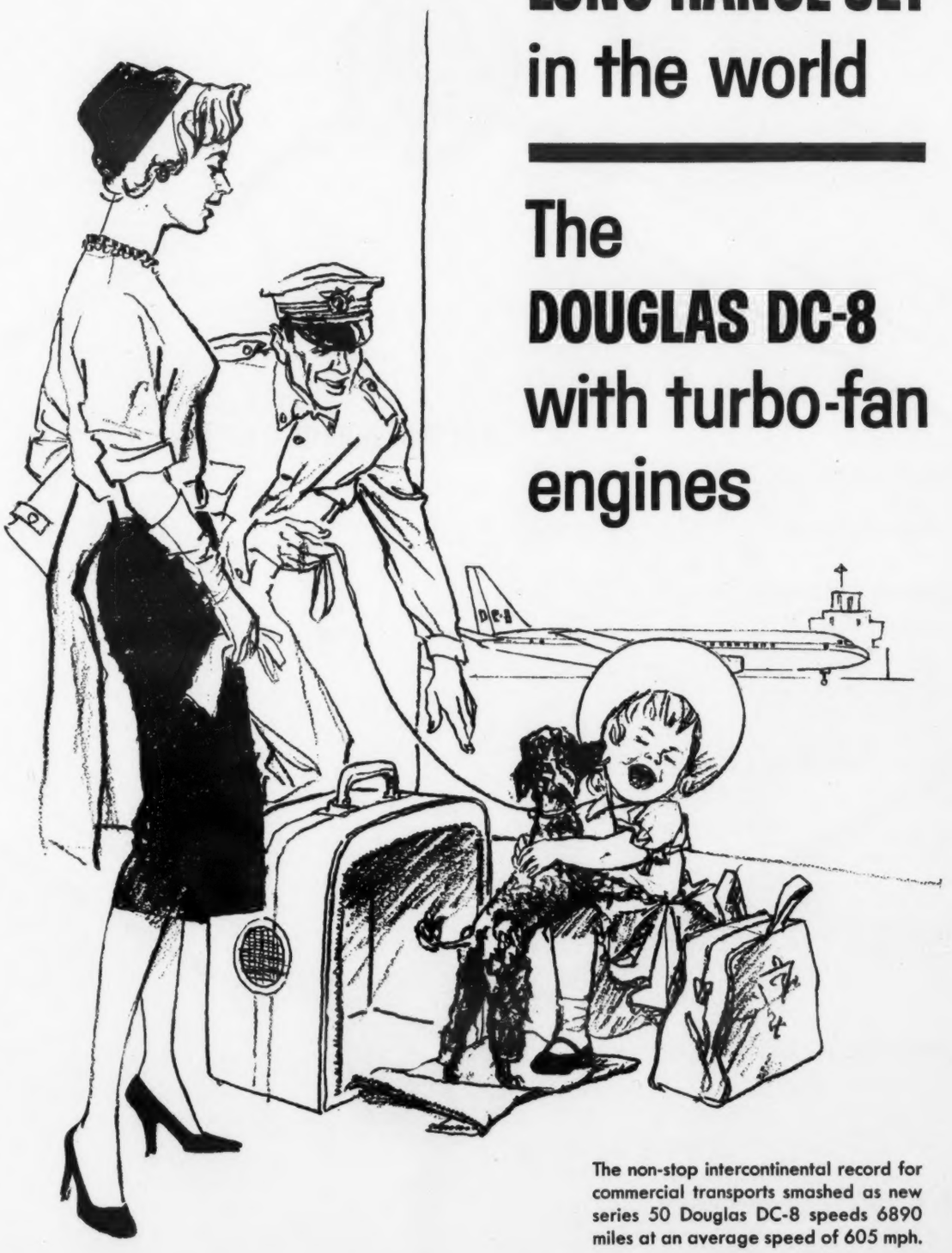

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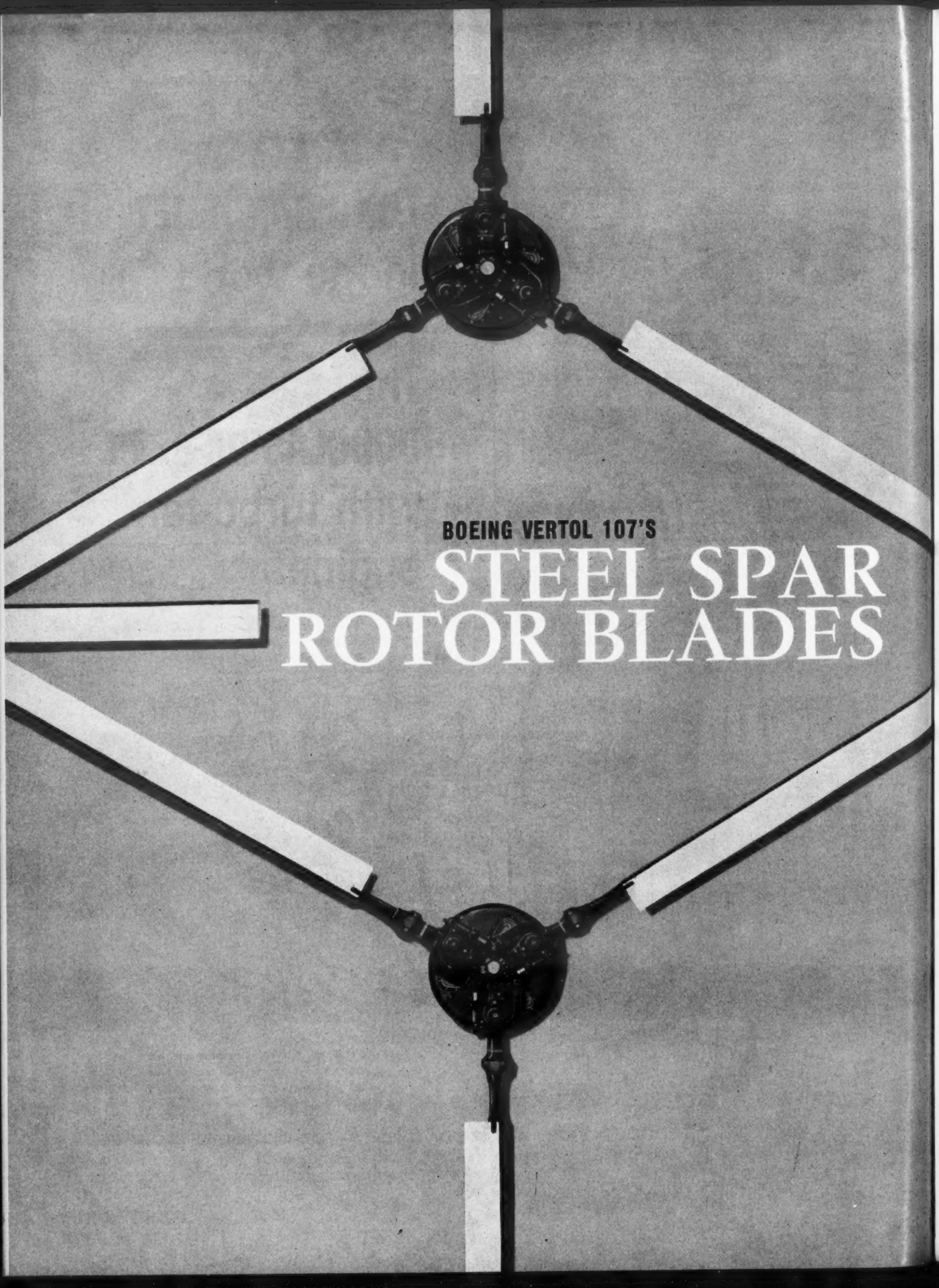

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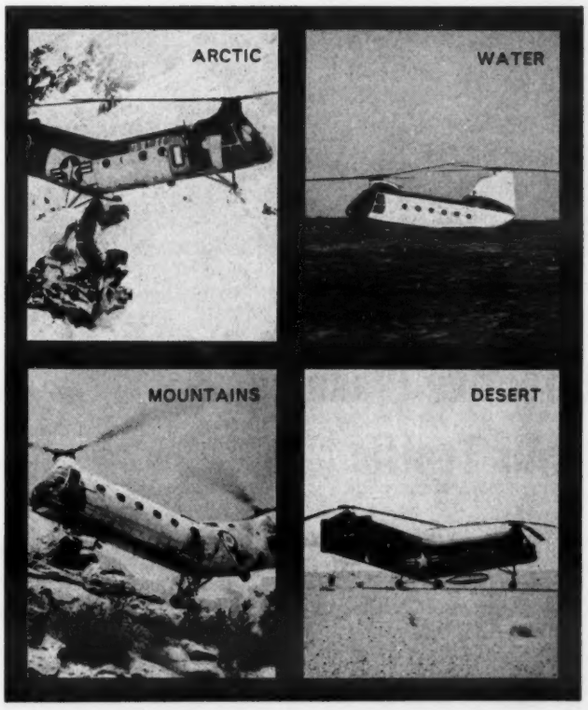

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Undecided Armaments Race?

Shortly after taking office, President Kennedy got down to a revision of the Defense Budget for fiscal 1962. The background was the incipient crisis over Berlin, and the subsequent decisions of the Senate, the House of Representatives, and the strategists were accompanied by ominous rumblings from that quarter.

Then came the Soviet success in launching Major Gagarin into space on April 12th, which filled the headlines and captured public imagination all over the world, and put the American space planners into a quandary. There seemed no room for doubt as to the authenticity of the triumph achieved by the Russians with their spaceship *Vostok*, and the Americans were obliged once again to admit that they had been pushed back into second place as the result of the concentrated effort of their great rival.

For the time being, the only counter-measures open to the leading statesmen in the USA were, so to speak, earthbound and, in view of the further developments as regards Berlin, they were forced to retaliate by strengthening conventional armaments. Whilst Soviet rocket engineers were preparing their next surprise moves in the race for space, the Senate Appropriations Committee unanimously voted an increase in defence expenditure by a total of $4,500 million, namely $1,000 million more than the increase President Kennedy had asked for, this total being predominantly for conventional forces. At the same time, Congress empowered the President to recall 250,000 reservists to active duty and to extend the period of service of those currently with the colours. This year's defence expenditure, in excess of $47,500 million, is the highest since the end of World War II and amounts to $6,500 million more than the estimates for this budget period authorized by Congress.

The Berlin crisis is, however, not the only factor behind the heightened American morale and the return to conventional armaments. In fact, there are a number of reasons, particularly the grandiose display put on by the Red Air Force when showing its new face at Tushino in mid-July. A dozen modern aircraft were there to prove that, contrary to the assumption of the White House and the Pentagon, the USSR has in no way dispensed with its conventional air forces. There were new supersonic bombers for strategic and tactical roles, single and multi-jet supersonic fighters, large helicopters, VTOL aircraft of the convertiplane type, and jet seaplanes, as well as nearly a dozen airborne missiles of a wide variety of calibres and applications... all of which raises the question as to whether the Americans were well advised, a few years ago, to concentrate their main effort on the development of long-range rockets, the more so as they have not been able to achieve a clear-cut advance even in this field.

Thus Kennedy's policy, as enunciated in this six-point programme of July 26th, of retaining in service numerous ships and aircraft (including 270 obsolete B-47 jet bombers) scheduled for scrapping, the US authorities' request for an extra $525 million for long-range bomber production, and the authorization of $448 million for further development of the North American B-70 into a comprehensive weapons system can all be seen as an initial reaction to the Soviet show of strength.

But are such measures really adequate, seeing that they come so late? Was it the responsible politicians who, over the last few years, demanded cuts in the B-70 programme and a stop to F-108 supersonic fighter development? Or should these weighty decisions to run down manned combat aircraft be attributed to misinformation previously supplied by the US intelligence agencies? These are perplexing questions. In any event, an unbiased appreciation of possible military operations in connection with Berlin already shows that the USSR would, at any time, be in a position to involve the Western defenders in the type of war which, like that of 20 years ago, though fought of course with more modern weapons, would start with a battle for supremacy in the air.

Who can, moreover, know for certain whether the Soviet Union has not made new advances in the field of small tactical nuclear weapons too? Such weapons could—if the Kremlin thought fit—be used in any theatre by infantry, tanks, or the combat aircraft demonstrated at Tushino.

Then, on August 6th and 7th, the Soviet spaceship *Vostok 2*, with Air Force Major G. S. Titov on board, circled the earth seventeen times before landing safely on Soviet territory. Only a few scientists and engineers, those entrusted with the preparations of such an operation, are in a position to gauge the real significance of this success. However the Soviet Union's manned thrusts into space may appear in detail, to underestimate its efforts and achievements in the field of space flight and space research at this moment could have catastrophic results. Possibly it is this that the Russians wished to demonstrate.

In any case, one cannot get round the fact that, in the last ten years, the USSR has made systematic advances in all spheres of defence technology, and is endeavouring to leave the West standing. Nor can this threat be met merely by increased military expenditure on the part of the NATO powers. As a first priority, Western armament production should be re-planned and definite tasks allotted to the industry in each country.

It will not do if, for reasons of prestige, all the major NATO powers pursue their own development programmes, with resultant duplication or triplication of effort and expenditure. Available industrial potential must to be utilized in such a way that individual countries specialize and each one does not attempt everything. Not least, in view of the East-West competition centred around the countries that are still developing, more attention must be devoted to the economic side of defence planning, if world peace is to remain assured through a dead heat between the world's two great power blocks.

•

Now is Farnborough time and, on the next page, our London Editor discusses the changing pattern of British defence and armaments policy. Then, against this background, we assess the outlook for the British aviation industry, which can well hope to benefit — in the shape of badly needed orders — from the rationalization of NATO armament production just referred to. In any event, it now appears that, after two world wars, Great Britain is altering for good some of the "isolationist" elements in her policy towards Western Europe. ←←

Britain's Defence Policy

"The primary purpose of our defence policy is, therefore, that it should protect us, our allies, and our friends against the whole spectrum of possible aggression and military threats, from the small local action which might be the beginning of larger and more dangerous adventures through 'nuclear blackmail' to nuclear war."

The British Government
White Paper on Defence, 1961.

By Derek H. Wood, INTERAVIA, London.

For years, defence has been one of Britain's thorniest problems, as succeeding ministers have tried to grapple with the dual requirements of a nuclear deterrent and adequate conventional arms. Recently, there have been encouraging signs that the present Minister of Defence, Mr. Watkinson, has gone some way towards reconciling the two extremes within the framework of a limited budget.

The thermo-nuclear deterrent is now firmly based on the "V" bomber force of *Victors* and *Vulcans*, and it has been stated that it is the intention to maintain this to the end of the decade. Improvements in Soviet fighter and anti-aircraft missile defence will, it is hoped, be offset by steady improvements in electronic countermeasures and by the use of the *Blue Steel* stand-off bomb and the *Skybolt* ballistic airborne rocket. Conventional arms have been receiving greater priority, and the Kuwait crisis showed that Britain has profited from the errors shown up during the Suez Canal operations. At the time of Suez in 1956, Britain had no tank landing ships in the area, only one heavy lift ship was available in the United Kingdom, and the stockpile of weapons lay in Egypt in Colonel Nasser's hands.

At Kuwait, well-armed and highly trained forces were being disembarked and deployed for action within 24 hours of warning being given. Tank landing ships put *Centurions* ashore, and a complete marine commando was supplied from the commando carrier *Bulwark*.

Having reached the stage where the two ends of the battle scale are better planned and better equipped, the Minister of Defence has been taking a long-term look at the situation as it will be in 1970, for it is here that the country faces its major problems.

By 1970, the deterrent will obviously have to be available in some new form, most probably as a combination of a successor to *Skybolt* and a successor to the "V" bombers. In the conventional field, there will have to be new equipment for all three Services, with a great increase in firepower from the infantry level upwards.

Beyond this looms the exceptionally difficult task of maintaining communications with the Commonwealth and the strategic stockpiles over distances of 10,000 miles and more. Normal radio techniques will be susceptible to jamming, submarine cables can be cut, and even forward scatter techniques will be blotted out by nuclear explosions in the upper atmosphere. This has led to Britain's defence planner's making a much closer examination of the question of space communications involving radio satellites, and also a hard look at the need to interrogate, and if necessary destroy, hostile satellites.

The question is how all or part of these programmes can be tackled within a budget that is unlikely to exceed the present £1,655 million per annum, and in face of the current balance of payment difficulties.

It now seems certain that future defence planning will be based on interdependence in three different spheres. First, the nuclear deterrent: ballistic missile early warning and defence against long range missiles will entail even closer co-operation with the United States, and discussions to this end have already been held between Professor Zuckermann, Chief Scientific Adviser at the British Ministry of Defence, and John Rubel, Assistant Secretary of Defense in the Pentagon.

In the tactical field, which includes a wide range of aircraft, guided weapons, armoured vehicles etc., it is expected that co-operation will be with Europe, and high level discussions which have been going on this year towards joint programming between the British and French, British and Germans, and latterly the Italians, are likely to bear fruit. The British Defence Ministry is now fully aware that joint specifications at the outset are essential, and that the research and development costs must be shared between the NATO countries without regard to who is the prime weapons contractor on a particular unit. The most likely projets on which collaboration will be firmly established from the outset are vertical takeoff strike aircraft, and the low altitude weapons system for defence against both low flying aircraft and field weapons.

Commonwealth defence provides the third range of co-operative agreements, and here the requirements tend to differ from those of NATO, owing to the distances involved. Exercise *Unison*, held in the United Kingdom in August by the Commonwealth Chiefs of Staff, and the conference of the Commonwealth Advisory Committee on Defence Science (which ran from July 17th to August 4th) have enabled a far firmer policy to be developed, both on the strategic placing of the forces available and the future requirements of research and development.

Britain has reached the production stage in her second generation missiles, and now faces the third stage of weapons and a new generation of manned aircraft. The successor to the "V" bombers is likely to be a very long range aeroplane carrying the *Skybolt* successor, but it is not yet decided whether this should be supersonic or subsonic.

The TSR.2 long range strike reconnaissance aircraft, despite constant sniping in many quarters, remains a firm project in which there is considerable interest in the Commonwealth, particularly Australia. With its 1,800-ft runway performance and high/low level capability, the TSR.2 looks most promising not only for the RAF requirements in Europe and the Middle and Far East but for the RAAF and its unusual operational needs in the north of the Australian continent. Possession by China of the atomic bomb would doubtless speed an Australian decision in this matter.

While TSR.2, as the largest British manned military project currently under development, is of Commonwealth interest, it also, to a large extent, fits United States strike requirements, and the British Government has been pressing the Pentagon to take a closer look at it and thus make interdependence a two-way instead of a one-way traffic. The British point to purchases of *Skybolt*, *Sidewinder* and *Bullpup*, and are suggesting that a little return buying would not be taken amiss. While TSR.2 does not fit directly into the NATO framework, its weapons system, now at an advanced stage, would be applicable to the second generation NATO VTOL strike aircraft. TSR.2 will have full sideways radar, terrain clearance, line-scan, and complete facilities for automatic simultaneous presentation on the ground. Use of the TSR.2 weapons system in NATO would undoubtedly save both time and a good deal of European research and development money.

The Soviet display at Tushino this year has led the Air Ministry to press the Government for continued, and even increased, development of manned aircraft. It is now abundantly clear that Mr. Sandys' policy of slashing aircraft in favour of missiles in 1957 has proved disastrous. A great deal of time was lost on airframes and engines, which is only now being recouped. The RAF hopes that the same process will not be repeated as far as 1970 projects are concerned.

On guided weapons there are many more requirements than there are development contracts. The following is a list of some of the weapons currently being studied by the Services:

1) A stand-off missile for TSR.2.
2) A long range successor to the *Red Top* air-air missile, for both the RAF and RN.
3) A longer range development of *Blue Water* for the army.
4) PT428, a low-altitude weapons system project by B.A.C.
5) An anti-submarine airborne guided weapon.
6) A successor to *Seaslug 2*, for shipborne operation.
7) A second generation one-man anti-tank weapon.
8) Anti-ICBM defence weapons (in co-operation with the USA?).

The Royal Navy is also looking ahead to the next decade, and it is certain that the carrier and carrier-borne aircraft will play the major part in future planning. The *Polaris* submarine, while still nursed behind certain closed doors in the Admiralty, is beyond the British taxpayer's pocket—even if a requirement could be proved for it. A gift of either submarines or weapons would be the only way in which the Royal Navy could become *Polaris* operators.

Discussions on three new carriers are continuing and, if sanctioned by the Treasury, would form the backbone of the Navy from 1967 onwards. Substantial numbers of *Buccaneers* have been ordered for the present carrier fleet, but a supersonic strike-fighter machine would be needed as a successor — perhaps with variable sweep wings.

The Fleet Air Arm will require a helicopter to succeed the *Wessex*, and an airborne early warning aircraft capable of both upward and downward viewing.

The transport side of military planning has come to the fore in the past 12 months, both in the strategic and tactical spheres. Britain is likely to go ahead with a V/STOL transport in the AW.681/Bristol 208 category and also with an STOL assault transport. It is here that there could usefully be co-operation within the framework of NATO. ⟷

The second Hawker P.1127 on its maiden flight. Six of these aircraft are under construction and will be used in an extensive test programme to accelerate the development.

The Outlook for the British Industry

One of our Editors, who has just returned from a visit to the U.K., tentatively sums up the prospects for its aviation industry.

With the coming of September each year, the British aircraft industry cheerfully submits itself with good grace to the ordeal known familiary throughout its ranks as "Farnborough" or the "SBAC." Whatever the phrase used to describe the function of the Society of British Aircraft Constructors annual exhibition, whether it be "shopwindow of the industry," "international meeting place," or "sales exhibition," opinions within the industry are divided as to the wisdom of continuing it as an annual event. The arguments for, and against, this proposition are varied. One body of opinion points to the existence of three major European air shows and suggests that a biennial display to alternate with the Paris International Salon would be a more practical arrangement, particularly in view of the rapidly growing importance of the Hanover show. The advantage of this solution would be that the participating companies would be able to achieve greater originality in their publicity and sales campaigns, and there would be less hindrance to the work of the development and production departments. This argument can be expanded by pointing to the time scale now required for the development of a modern aircraft from the drawing board to a flying prototype or pre-production model.

Another opinion which has been expressed is that the exhibition should retain its annual timing and that there should be some modification in the presentation and programme. This might be termed the "best of both worlds" solution in as much as it would relieve the aircraft constructors of the expense (by no means negligible) of demonstrating aircraft which are already known and are commercially available. The actual cost of presenting an aircraft in the flying display at Farnborough is considerable, and it could well be argued that the expenditure of a similar sum of money in flying the aircraft to a foreign country and carrying out a sales tour would be more profitable. By retaining Farnborough as an annual event, the equipment and electronic companies, for whom this is a valuable shop window, and who conduct a considerable volume of business during the week, would not be penalized. As these companies numerically form the greater part of the membership of the SBAC, their requirement for an international "shop window" would be catered for and, at the same time, the aircraft constructors who are the major contributors financially would find their position eased. An arrangement such as this would result to a certain extent in a return to the atmosphere of the pre-war Hendon displays. The show would possess a certain "garden party" feeling in which members of the British industry could meet their friends from overseas aviation industries and renew contacts in an informal atmosphere. The flying display would be reduced in length, and would consist mainly of Service contributions together with the presentation of new aircraft by the test pilots of the industry.

This solution may possibly be the best and it certainly displays the British characteristics of improvisation and compromise. As no definite proposals have been made as yet on the necessity to remodel the pattern of the Show, it is perhaps idle to speculate on future possibilities. One concrete fact remains: September, 1961, is upon us and with it the twenty-second Society of British Aircraft Constructors Exhibition.

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It has become traditional for *Interavia* to carry out a review of the British aviation industry prior to the SBAC Show each year. As 1961 was also the year of the Paris Salon, much has already been said in these pages concerning the current programmes of the British industry. On this occasion it would be more profitable to look at the industry itself and the economic framework within which it has to work.

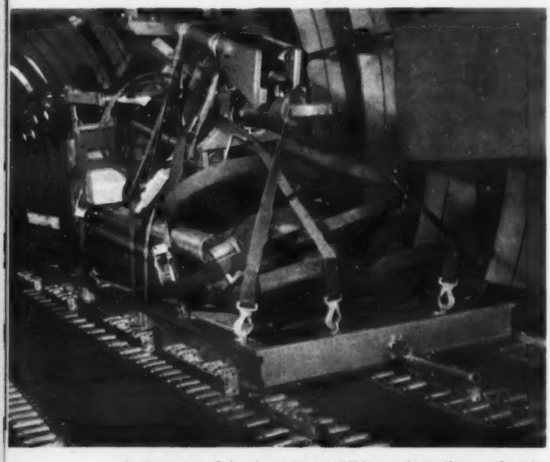
Some eighteen month have elapsed since the Government-sponsored programme of amalgamation and mergers commenced. The revolution was violent and at the time of the last Farnborough show it was incomplete. Old rivals were undergoing the difficult changes of heart and outlook which were required to enable them to accept new and unusual alliances. It was then too early to more than hazard a guess at the outcome, and the wits within the industry gave free play to their imaginations in satirising the new and unusual situations which arose. By now the process of amalgamation is well advanced, if not complete, and judging from reports from within the industry, the new groupings are working excellently and with no visible signs of friction. It is generally agreed that, despite the regret which arises when a famous name is submerged within a large Group, this is more than outweighed by the advantages which accrue. In fact, without this regrouping, the industry would have been extremely ill-equipped to face the mounting competition throughout the world.

In certain respects the character of the British aircraft industry is unique. The construction of aircraft, engines, components and anciliary equipment is an activity which fits ideally into the general economic structure of British industry. In a country where the whole economic pattern and in fact the standard of living is geared to the

necessity for maintaining a satisfactory excess of exports over imports, the aviation industry presents many attractive features. It is sparing of raw materials, many of which are only obtainable from foreign sources, and the relationship of the price of the finished product to the price of the raw material is extremely high. The selling price—apart from being an addition to the country's export figures if the finished product is sold abroad—largely represents the price paid for design and manufacturing skills and processes.

Against this advantage must be set a considerable difficulty. It has usually been held that the basis for a satisfactory export trade is a healthy domestic market. In this respect the United Kingdom is singularly badly situated. Apart from the nationalized Corporations: British Overseas Airways and British European Airways together with the recently emergent independent operator, British United Airways, there is little in the way of a domestic market for the industry to base its export trade upon. Furthermore, the aircraft requirements of the British operators are in no way comparable to those of the American companies, which presents another difficulty in breaking into the much sought after and dollar-profitable American market.

The Armstrong Whitworth *Argosy* has been designed specifically to meet the requirements of freight carriers. Its performance in commercial operations indicates that there are excellent sales prospects for this aircraft.



A close-up of the Armstrong Whitworth *Rollermat* freight loading system which is installed in the *Argosy*. The simple method of pallet retention is clearly visible in this picture. The removal of the end blocks leaves the pallet free to be rolled out of the hold.

The first advantage of the regrouping is that the variety of products and projects within the industry has been streamlined and a great deal of duplication of effort and internal competition has been eliminated. This has come at an opportune moment because some falling-off can be anticipated in the level of export figures in the next twelve months. In 1959, the exports by the aviation industry attained a record figure of £156 million and in 1960 they were some £14 million lower at £142 million. The figures for the first few months of 1961, when estimated on an annual basis, amount to the very healthy total of £165 million, but it must be borne in mind that this covers the delivery of aircraft which were ordered some time ago and which will have been completed before the end of the year. When these orders have been fulfilled there will be a delay before the flow of next generation aircraft commences.

In spite of the lack of a large domestic market, the steadily increasing volume of exports from the industry since the war has indicated there has been no lack of either ideas or effort from the individual companies. Some measure of assistance has been obtained from Government defence spending over the past years and this has provided a certain stability. It was to augment this stability and to eliminate unnecessary competition that the Government insisted on the amalgamation programme.

A brief review of the current British projects gives some indication of how long the gap will be before the next generation aircraft come off the production lines and export figures rise again.

In the civil aircraft field, the British manufacturer faces vigorous foreign competition in terms of the number of aircraft on offer from the US, France, Canada, and Holland. Taking the case of the long-range aircraft first, the current project in this category is the Vickers VC.10. This illustrates the peculiar difficulty facing the British designer who is compelled to tailor the specifications primarily to the requirements of the long distance carrier BOAC. To fill the needs of the route pattern operated by BOAC, an aircraft suitable for what are termed the "Empire routes"

Production of the *Argosy* in progress. The *Dart* engines are in process of installation.

is required. This indicates an aircraft having good short field performance, capable of operating from high altitude airfields at high temperatures, and consequently possessing an excess of performance for the requirements of the North Atlantic route. The American designer, on the other hand, with a large domestic market to satisfy, can concentrate on the "North Atlantic" aircraft without becoming involved in meeting the specialised requirements of a particular carrier. At present Vickers have VC.10 orders in hand for BOAC, British United Airways and Ghana Airways, and the company is confident that the performance and economics of the aircraft when it goes into service will make it an interesting proposition for operators who will be either re-equipping or modernising their jet fleets in the mid 1960's. If there is a renewed spate of activity in the jet market in three or four years time, the VC.10 will have one telling advantage over its competitors, namely availability.

In the medium and short-range field, the British industry also faces competition. The de Havilland *Trident,* a medium-range three jet aircraft, is on order for BEA and a vigorous sales campaign is being carried on throughout the world airline industry. The most serious competitors in this field are the *Caravelle* and the Boeing 727, and although the current 727 order book is larger than that of the *Trident* the aircraft should be available earlier. At least one American airline has expressed serious interest in the *Trident* to date and as the aircraft will enter service equipped with provisions for fully automatic landing this will be a powerful sales feature for all airlines who are endeavouring to improve the regularity of their schedules.

The short-range aircraft, the BAC *One-Eleven,* which is now under construction at Vickers, is described in a separate article in this issue. Designed as a jet powered replacement for the *Viscount,* this aircraft has been planned to offer the maximum economy both in initial investment and operation, so that it should be attractive to a considerable number of the smaller airlines and domestic operators who will be able to offer jet speeds over short haul routes to the passengers. Now that the long range jets are fully established in service, it will be aircraft of this type which will introduce the biggest revolution in the pattern of air transport.

In the civil market, one other important type remains to be mentioned, this is the Armstrong Whitworth *Argosy* freighter. This is important on two counts, as apart from being one of the few British aircraft to have broken into the American market in recent years, its performance in service has been outstanding. Daily utilization rates of thirteen hours have been attained and this performance has had a significant effect on the economics of freight carriage. Interest in the *Argosy* is steadily increasing among freight operators so the prospects for its future seem excellent.

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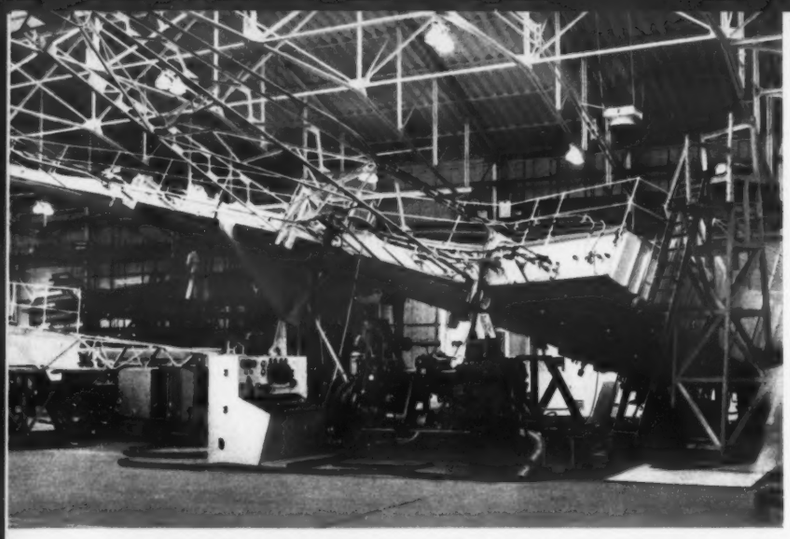
In the military aircraft market the prospect of diminished export figures for a period is also likely. Current contracts are being completed and there may be an interval before new developments are available. There are excellent forward prospects for the sale of fighter aircraft within NATO and the British constructors are fully aware of this market. Such aircraft may well be built in cooperation with other European countries and it is significant that the main political topic in Great Britain at the moment hinges on the proposal to join the Common Market.

There is a requirement both by the Royal Air Force and the NATO forces for a light tactical fighter with VTOL capability. The Hawker P.1127 is well advanced in development and is an obvious contender. Design work is at present being

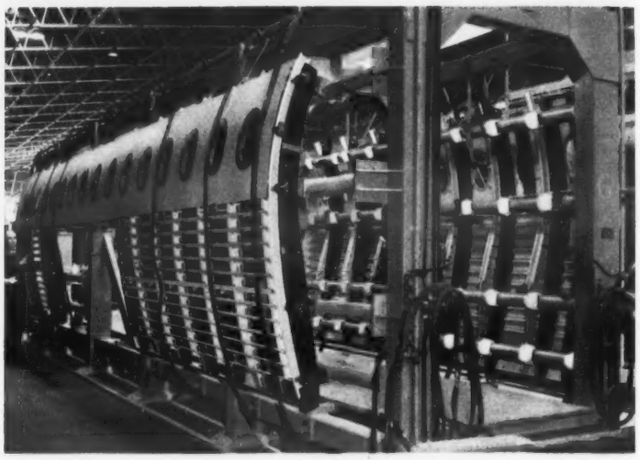
An artists impression of the Vickers VC.10 long-range airliner. The VC.10 is powered by four Rolls-Royce *Conway* engines and has already been ordered by three airliners.

The fuselage of the first VC.10, being moved from the assembly jig to the assembly hangar for next production stages. The aircraft will seat up to 150 passengers and will be in service with British Overseas Airways in 1963.

Another completed export order. A Vickers *Vanguard* in the livery of Trans-Canada Airlines stands at the manufacturers airfield prior to its delivery flight. The *Vanguard* is in full production at the Vickers plant in Weybridge.

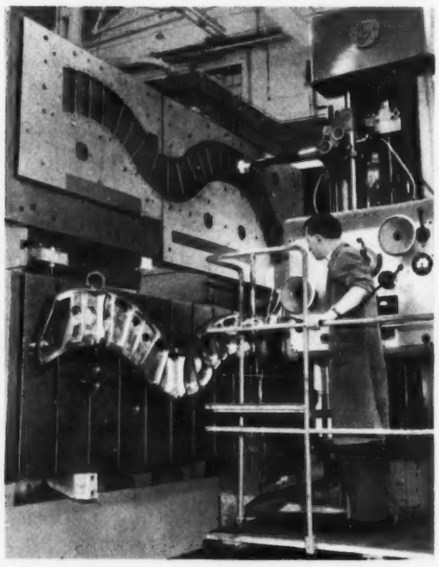


A full-scale VC.10 test wing installed in a special rig for fuel flow and gauging tests. The wing can be positioned in any flight attitude so that the continuity of the fuel flow can be tested under all conditions.

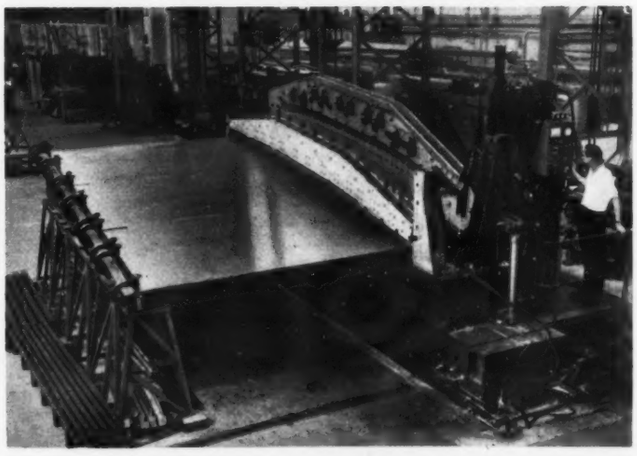


One of the long fuselage side panels, containing the window cutouts, is hoisted into position on the fuselage assembly jig. The panel is machined from a solid light alloy billet and carries integral stiffeners around the window panels.

The Vickers VC.10 Production Line



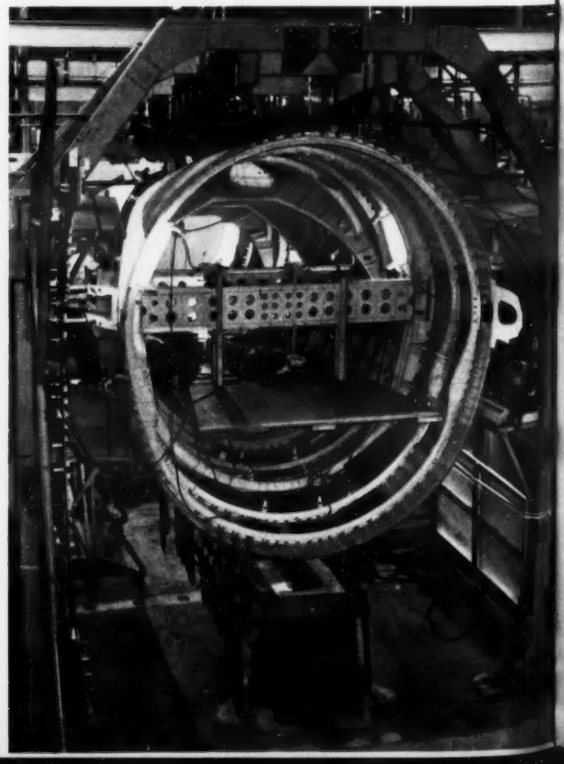
An engine mounting beam being cut from solid metal. The cutter movement is controlled by an electronic system from a stylus which moves around the template mounted on the upper part of the machine. The billet of raw material for this component weighs 1,344 lb and the finished beam weighs 140 lb. The total machining time required for this operation is 500 hours.



A variable angle contour milling machine which was designed by Vickers specifically for VC.10 production, is used at Weybridge to machine the combined twist and dihedral angle on the wing centre section panels.

The main wing structure of the VC.10 in the jig. The multiple torsion box structure is built in three main sections, namely two mainplanes and a centre section. In the skinning of the wing, eighty machined panels with integral stiffeners are used on the upper and lower surfaces.

A rear fuselage about to be removed from its assembly jig. The transverse beams passing through the fuselage have end fittings which carry the half spectacle engine mounting frames. The three machined frames in an inclined position at the rear of the fuselage carry the vertical fin.



carried out at Hawker Aircraft on a supersonic development of the P.1127 designated P.1150. This would be powered by an uprated BS.53 *Pegasus* engine with plenum chamber combustion (PCB). The decision to build VTOL aircraft in quantity will probably be made this year and the construction will possibly be carried out in co-operation with France and Germany. If this occurs, the ground will have been prepared for the cooperative production of a heavy VTOL fighter which will be required by NATO in the mid sixties.

Within the British Aircraft Corporation, the English Electric *Lightning* is in full production and development of the TSR-2 by a combined Vickers/English Electric team is well advanced. This particular aircraft should provide work for these factories for some years to come. The TSR-2 is designed to be a tactical, strike and reconnaissance machine to replace the *Canberra* and its advanced electronic equipment will provide it with capabilities which will make it attractive to both foreign and Commonwealth air forces.

In the Hawker Siddeley Group, the Hawker P.1127 is obviously the aircraft of the moment. The recent emergency in Kuwait underlined the need for a tactical aircraft with VTOL capability, so it would be reasonable to anticipate that the future of this aircraft or a supersonic derivative is assured. Also within Hawker Siddeley, the production of the Blackburn *Buccaneer* is increasing. Blackburn already has a Naval order for the aircraft and interest has been expressed by foreign buyers, in particular West Germany. The very heavy construction of the *Buccaneer* gives it considerable growth potential and with more powerful engines it will be capable of supersonic flight at low level.

No new aircraft has been announced in the bomber category, and it is reasonable to suppose that the V-bomber force will continue in its present form for some time to come. *Vulcan Mk2* are being issued to the V Force squadrons at present and it is clear that for some years the deterrent force will be based on *Victors* and *Vulcans* carrying the *Blue Steel* stand-off bomb and also from 1964 onwards, *Vulcans* carrying the Douglas *Skybolt* air launched ballistic missile.

Other military orders which can be counted on to maintain the turnover of the industry will stem from the requirement for transport aircraft. Three main types can be mentioned in this connection: the *Argosy* with beaver tail for load dropping and parachuting, the Short *Belfast* heavy turboprop strategic transport, and in the helicopter field—the Westland *Belvedere*.

Westland Aircraft, the group specializing in helicopters, also has substantial Service orders on hand for the *Scout* army helicopter and the turbine powered *Wessex* for the Navy.

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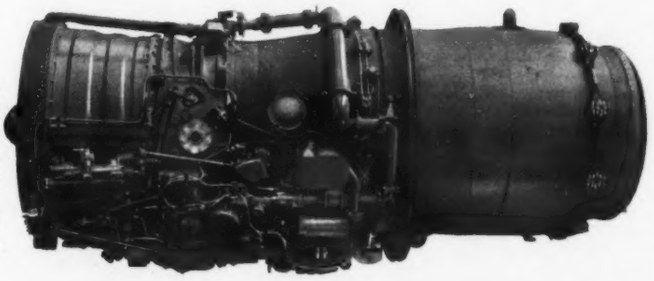
The Engine Manufacturers

Since the amalgamation programme, two major engine manufacturers remain: Bristol Siddeley and Rolls-Royce. In both companies the problems of VTOL propulsion occupy a major part of the effort.

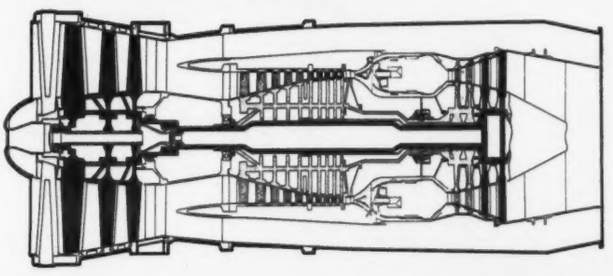
At Bristol, development work is being done on the BS.53 and studies are being carried out on an uprated version. Great advances have been made in the use of plastics for the cool areas of the engine, and components such as compressor intakes and entry guide vanes have been produced in material that is both lighter and stronger than metal. Plenum chamber combustion, the heating of the cool airflow from the fan of ducted engines, is also the subject of intensive research. Another recent addition to the Bristol range is the BS.75, a high-ratio ducted fan with a take-off thrust of 7,350 lb (3,335 kg) and a specific fuel consumption of 0.50 lb/lb/h. The *Olympus* engine is installed in all the Vulcan bombers of the V Force and it is being intensively developed for the TSR-2 tactical/strike aircraft. An advanced version of the *Olympus* develops 33,000 lb thrust with reheat, which is indicative of the engines' potential. A civil version of this engine would be an obvious possibility for installation in a supersonic civil airliner if the decision to go ahead with such a project is finally made.

At Rolls-Royce the situation is somewhat different in that development work is in progress on engines which have already been specified for particular aircraft. These are the *Conway* which will power the Vickers VC.10, and the *Spey*, selected for the *Trident* and the BAC *One-Eleven*. Much of this work is centred on noise reduction and for this reason Rolls-Royce is reluctant to employ by-pass ratios much greater than unity in the new generation of engines. Although the selection of the optimum ratio is dependent upon a wide variety of factors it has been found that increasing compressor noise from the high ratio engines offsets the reduction in takeoff noise. This is particularly apparent in the landing phase when the engine intakes are pointing toward the ground.

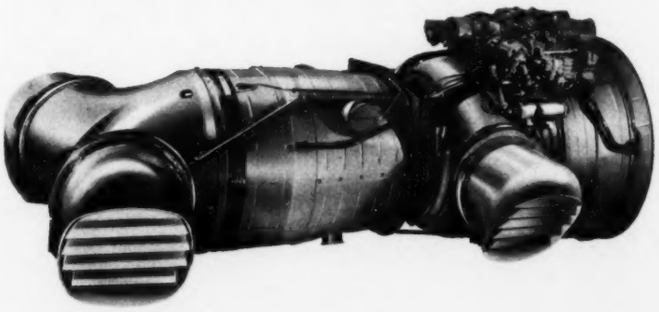
With the recent amalgamation of the engine division of D. Napier and Son with Rolls-Royce, the Derby company also enters the field of turbine helicopter engines. Apart from the development of the *Tyne* for the *Rotordyne*, this is the first venture into this field. The prospects for the Napier *Gazelle* are extremely promising and they should be further improved with the assistance of the sales and service facilities possessed by Rolls-Royce.



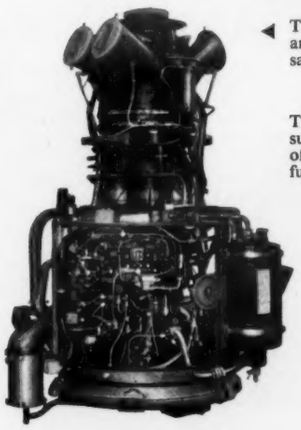
The Rolls-Royce RB.163 *Spey* by-pass engine of 9,850 lb thrust. This engine will be installed in the de Havilland *Trident* medium-range aircraft and the BAC *One-Eleven* short-range transport. A ministry of Aviation contract was placed early this year for a military version of the *Spey*.



Cross section of the Bristol Siddeley BS.75 ducted fan engine. The two spool layout and large by-pass system are clearly shown. The by-pass ratio of the engine is 1.75:1.



The Bristol Siddeley BS.53 *Pegasus* lift/thrust ducted fan engine. This is the power unit for the Hawker P.1127 VTOL aircraft. Design work is also in progress on an uprated version of this engine for heavier VTOL aircraft.



◀ The Napier *Gazelle* turboshaft engine for helicopter applications. The recent amalgamation of Napier with Rolls-Royce will doubtless result in improved sales prospects for this powerplant.

The de Havilland *Gnome* turboshaft engine which has recently scored export success in Australia and Italy. The engine is the British licenced version of the American T-58 and the main difference is the fitting of an electronic fuel computer in place of the original mechanical system.

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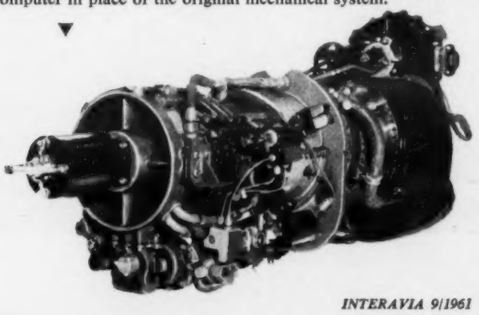
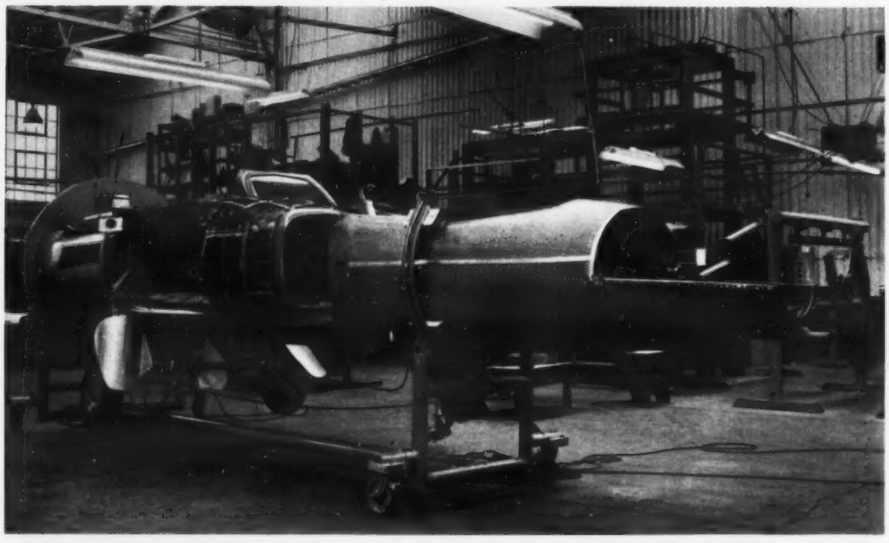


The Missile Industry

Turning from the airframe and engine constructors to consider the prospects of the British missile industry, the situation here seems rather complex. The industry is still young and in the twelve years or so of its existence it has steadily built up teams of scientists and designers specialising in the missile field. The success of their efforts is illustrated by the recent export orders amounting to about £80 million for *Bloodhound* missiles from Sweden and Switzerland, orders which were obtained in the face of international competition. At the same time it must be accepted that the first and second generation of guided missiles in Britain have advanced into the production stage and there is little in the way of Government assistance forthcoming for third generation weapons. At the moment the Treasury is providing only small amounts of money for design studies and this is resulting in difficulties for companies who lack any directive on future policy and requirements. An article on British Defence Policy in this issue (p. 1198) details a number of projects which at present are awaiting Treasury assistance. The complaints among the industry are not directed primarily against the lack of financial support, but against the lack of a firm programme that would enable the companies concerned to make a reasonable long term plan, as there are limits to the time that missile teams can be maintained in being without a contract.

Current activity within the industry includes production of the ground-to-air missiles *Thunderbird* and *Bloodhound* and of the Naval anti-aircraft weapon *Sea Slug* and the supersonic version *Sea Slug 2*. With the steady increase in the number of missile armed naval vessels either projected or in service, there are obviously increasing possibilities for the sale of the Short *Sea Cat* guided missile. This small weapon has been adopted by the Royal Navy as a replacement for the 40 mm anti-aircraft gun and the experience gained by Shorts during the development would obviously be an important sales factor. In the field of air-to-air missiles the *Red Top* is replacing the *Firestreak* and the Services are now anxious that development should be pushed ahead on a new long-range air-to-air missile. Prospects exist for further sales of ground-to-air missiles and also for army anti-tank weapons such as *Vigilant*, and assuming that the Government produces a long term plan for future procurement the general outlook for the missile industry is reasonable, although there may be some reduction in manpower.

The *Agricultural Gyroplane* first flew on July 20th, 1961. It is a joint product of D. Napier and Son and Pan-Britannica Industries Ltd. and designed for economical aerial crop-spraying. The makers claim that only ten hours instruction are required to pilot the *Gyroplane*. A remotely controlled version is also under development.



The fuselage of the Folland *Gnat Trainer* under construction. A recent order has been received for the supply of these aircraft to the RAF where they will be used to replace the present *Vampire* trainers.

The *Gnat Trainer* at a later stage in assembly. There is no limiting speed for undercarriage extension and the fairings on the front of the undercarriage struts act as air brakes.

The Equipment Industry

The term, equipment industry, covers a very wide and varied range of activities, from light engineering to electronics. A glance at the variety of equipment exhibited at Farnborough illustrates this situation. It is impossible to give a detailed review of the commercial prospects of such a broad field, but certain instances indicate that the British manufacturers and exporters have achieved some remarkable successes.

The Marconi Company is in the process of fulfilling a large order for Sweden which amounts virtually to the installation of a complete early warning and fighter control system. The recent Anglo-American agreement on compatible standards for secondary radar points to considerable activity for Cossor Radar and Electronics in the supply of this equipment for commercial aircraft. Similarly, in the instrument field, the advances made in automatic landing research will result in excellent prospects for companies such as Smiths, Standard Telephones and Cables and Pye who have contributed extensively to the progress made up to date.

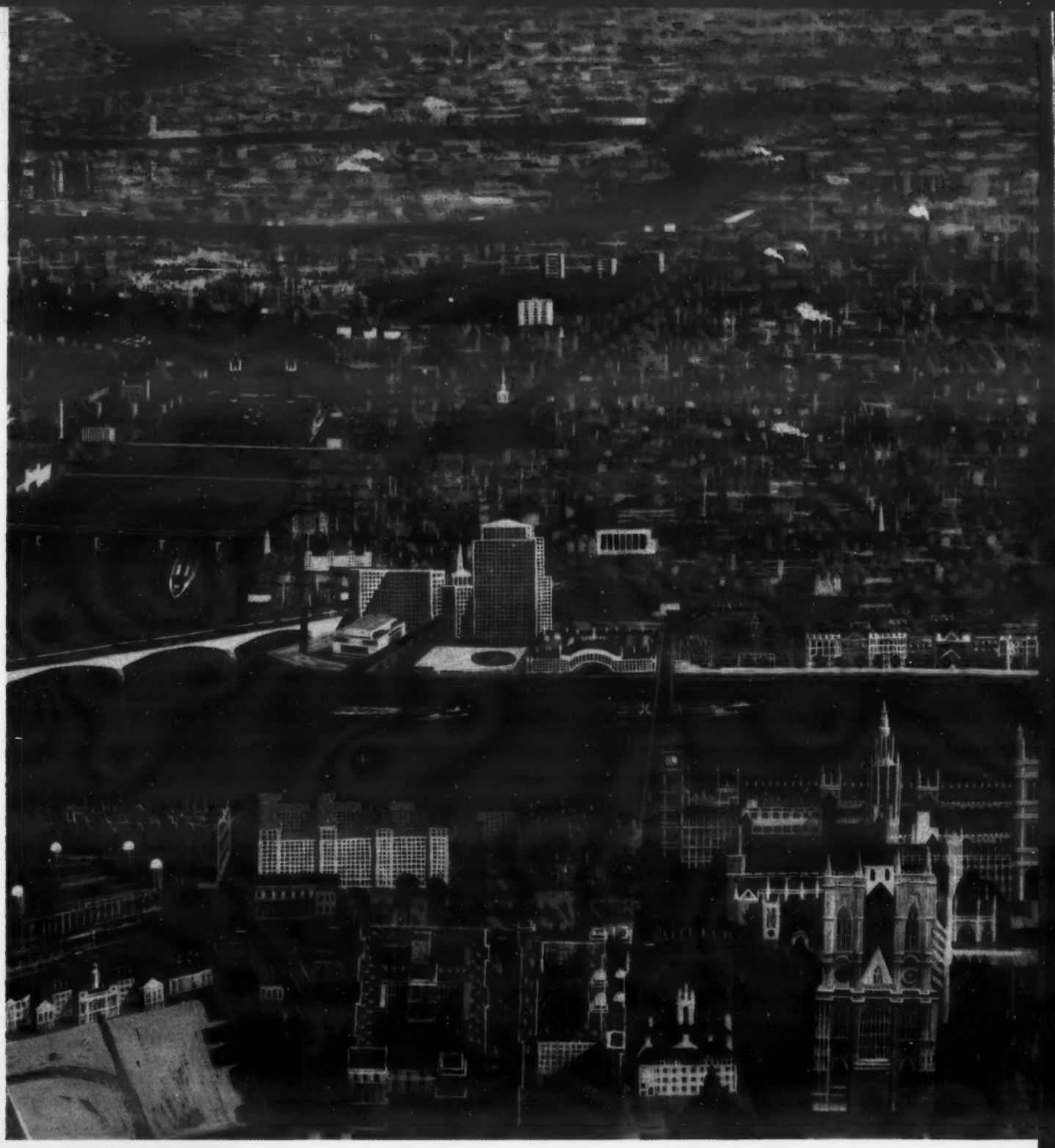
The Pye Instrument Landing System has been used by the Blind Landing Experimental Unit at Bedford as the primary guidance element in the British system of automatic landing, and this equipment has now been sold to 10 civil airports in the UK and to 20 overseas airports. It is also installed at 100 RAF airfields throughout the world.

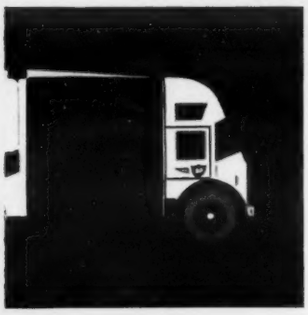
Future Prospects

A brief glance around the new projects which are in hand in all branches of the aviation industry reveals that there is no scarcity of new ideas and forward thinking, and the technical quality of the products which are available is equal to the best that foreign competitors can offer. The major difficulties facing the industry stem from commercial rather than technical problems.

In many of the past 15 years, Britain has faced an economic crisis and 1961 has proved to be no

Fast flying airlines . . .





. . . fast fuelling

AIR BP

London bystanders see, overhead, the airliners of most nations as they ply to and from London Airport: among them, most of the airlines fuelled by AIR BP on the world's air routes.

HIGH-SPEED FUELLING

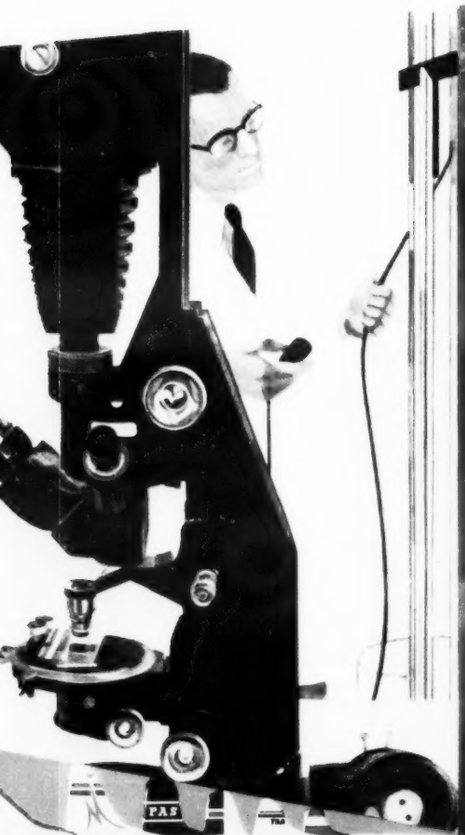
AIR BP has developed new high-speed fuelling methods with mobile Superfuellers. These are capable of fuelling at flow rates far greater than current aircraft can accept, and are thus equal to the demands of more advanced types to come.

MOST OF THE WORLD'S INTERNATIONAL AIRLINES ARE FUELLED BY AIR BP

CLEAN FUEL RESEARCH

AIR BP has carried out extensive research into the problems of micronic filtration and water separation at the BP Research Centre for many years.
An important part of the work is the full-scale testing of equipment under actual working conditions. AIR BP has developed a special test unit for this purpose and all equipment is rigorously tested before being accepted.

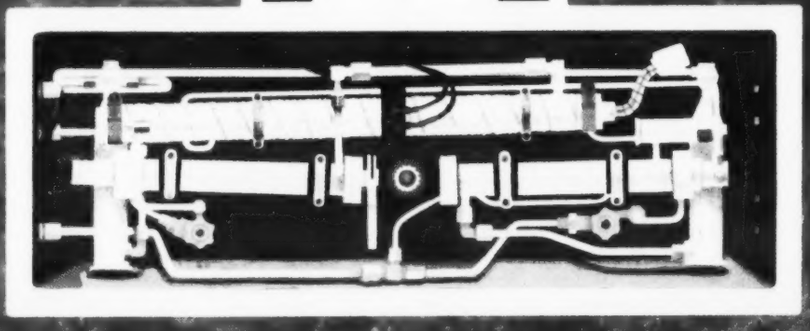
AIR BP



RESEARCH has a beginning, but—in AIR BP—no end. The guiding purpose of this continuous process is to be ready in advance of new requirements, so that whatever the aircraft industry may bring forth, a complete AIR BP service will exist capable of meeting all new demands in fuel specifications and fuelling techniques.

Now AIR BP Clean Fuel Research produces

BP AQUASCAN



This new instrument continuously samples every gallon of fuel during delivery for the presence of undissolved water. This is the first successful device of its kind—simple and compact, ideal for use at airport service. BP AQUASCAN is the latest development in the AIR BP Clean Fuel Research programme and will consolidate the Company's lead [illegible] this vital [illegible].

As fuel is delivered, a continuous sample is drawn through [illegible] (A) and air separator (B1).

Half of this sample is then heated (C1) to remove any suspended water and enters one cell of the comparator (D1) via a further air separator (B2).

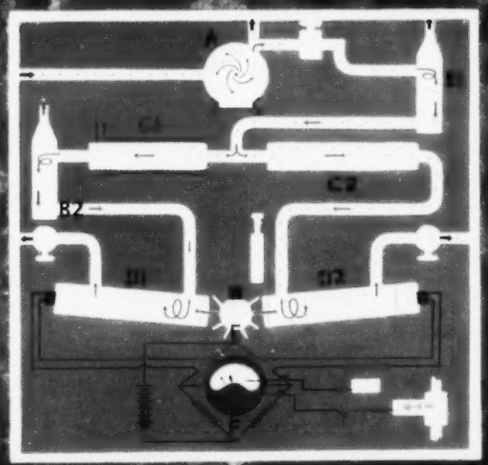
The remainder passes directly into the other cell (D2) through a Balancing Coil (C2).

Light from a single source (E) is passed through both cells and compared photo-electrically.

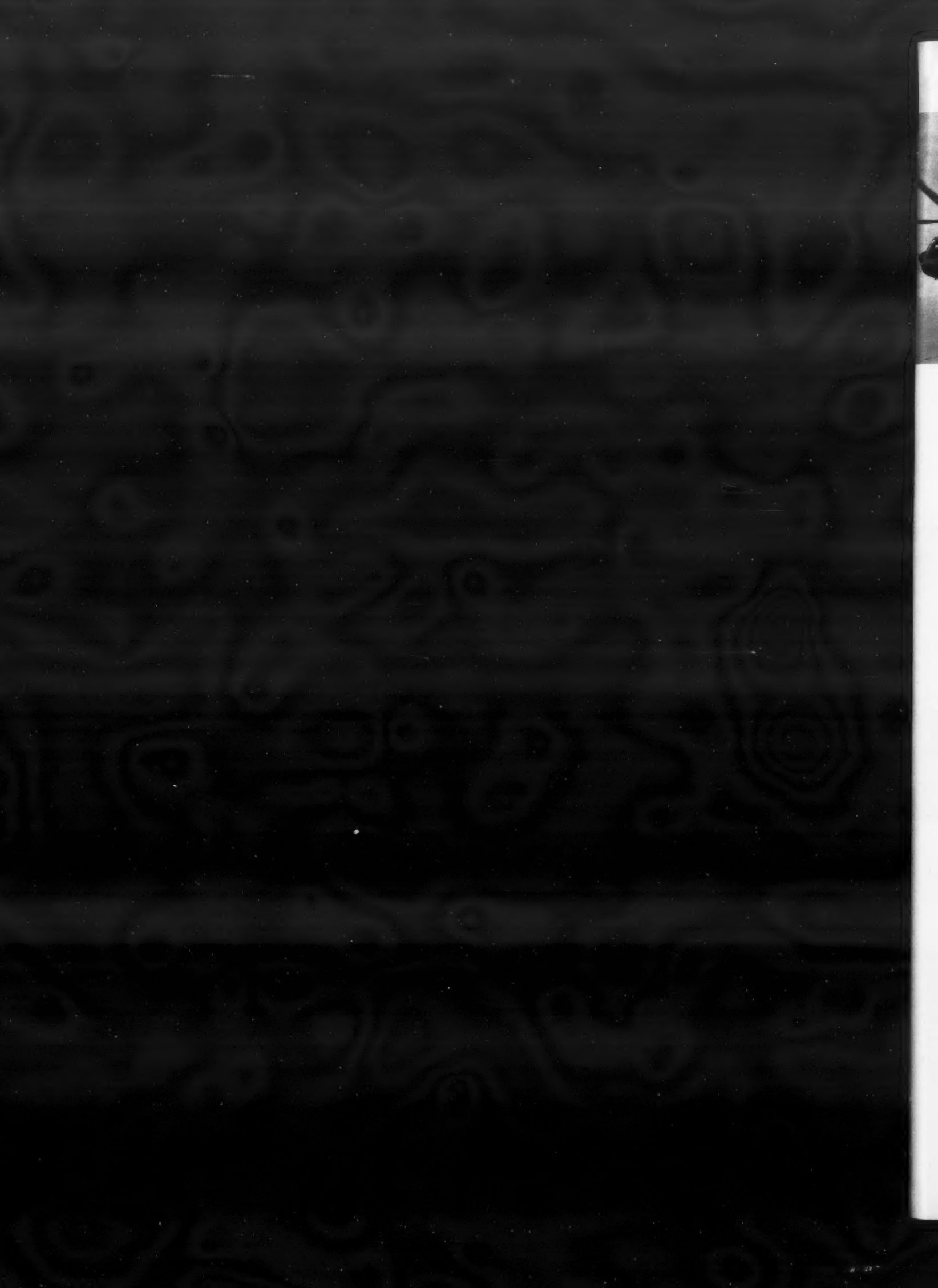
Any undissolved water in the unheated sample will cause more light to be absorbed than in the heated sample.

This difference in light absorption is measured on a dial (F) calibrated in parts per million undissolved water to fuel.

When a pre-set limit is reached, delivery of fuel is immediately cut off.



BP Aquascan *continuously* samples fuel for undissolved water, *simultaneously* cuts off fuel delivery at any predetermined setting if unacceptable amounts of undissolved water are present. BP Aquascan, now being fitted to [illegible] is a major technical achievement.



The Westland *Belvedere* which has been ordered by the RAF. It is powered by two Napier *Gazelle* turbines of 1,650 s.h.p.each. The *Belvedere* is capable of single engine flight when fully loaded, a factor which points to its suitability for civil transport from city centre to city centre.

The Westland *Whirlwind Mk.*10 powered by the de Havilland *Gnome* engine of 1,050 s.h.p. The installation of a turbine engine has greatly increased the performance of the *Whirlwind* in comparison to the original piston engined version, particularly in conditions of high ambient temperature and at high altitude.

exception. The pattern of the current crisis is somewhat similar to that of its predecessors. The balance of payments is in deficit and in fact the figures for 1960 were the worst for ten years. Speculation against sterling has resulted in a flow of money out of London and this has been accentuated since the re-valuation of the D-Mark.

In previous years the reaction of the Government to a similar situation has invariably followed the same pattern. A reduction in consumer demand at home by credit restrictions and control of hire purchase, reduction in Government expenditure and an increase in the Bank Rate.

In July this year, the Chancellor of the Exchequer announced that measures would be taken to overcome this recurrent problem and for over a week British businessmen were left in suspense before the promised remedies were announced. The solution, when it appeared, seemed to possess a startling resemblance to the measures which have been tried without permanent success over the past fifteen years. Reduced Government expenditure and an increase in the Bank Rate to 7 percent, together with increased taxation on a number of consumer items, apparently were regarded as being adequate measures to strengthen the economy.

Faced with this almost annual atmosphere of crisis, it is not surprising that many businessmen look to the prosperity of their foreign competitors, and demand that a long term plan be established by the Government to enable them to meet the increasing competition from rapidly developing overseas industries. In the aviation industry for example, many executives point to the example being set by France, where the "loi programme" has at least given the French aircraft industry a broad basis for expansion over the coming years.

A further assistance to the aviation industry would be some form of aid for export finance. American aircraft manufacturers are able to offer far greater financing facilities to prospective buyers than are available to their British counterparts. The Export-Import Bank and also groups of American banking houses are willing to provide these long term financing facilities and this is a telling point when the capital cost of a modern aircraft is considered.

It is possible that this year should see some changes in this situation. It is the first year of the new international system whereby the International Monetary Fund will be used to assist nations over temporary deficits in payments. Britain has already made recourse to this measure this year and it is possible that the application of this system will free British manufacturers from the upheavals of a recurrent crisis and will give them a better opportunity for long term planning.

As an active exporter, the British aviation industry has little to fear and a great deal to gain from the proposed entry of Britain into the Common Market. The effects of this move will be more apparent, and also painful, to other industries which have been protected by relatively high tariffs. This is undoubtedly the long term policy behind the Governments intention to enter the European community and if this readjustment results in a healthier economic atmosphere, the aircraft industry will obviously benefit from the situation.

*

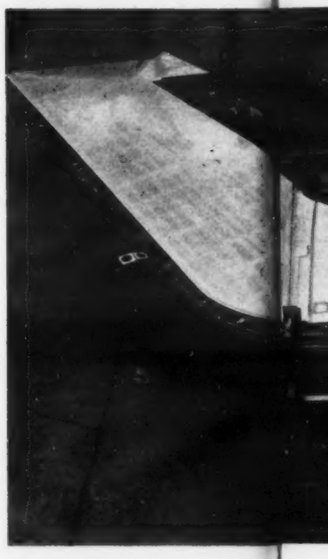
In conclusion, the prospects of the British industry can be summed up briefly by saying that the regrouping programme has streamlined the industry and has eliminated duplication of effort. The projects being developed in airframes, engines and equipment are competitive and technically excellent, but owing to a lack of Government policy the industry has been handicapped commercially. The famous (or infamous) Defence White Paper of 1957 can be held responsible for much of this, and it is only now that the individual companies are overcoming the delays which arose from the change of accent from manned aircraft to missiles. The pendulum has now swung the opposite way and at present the missile industry is faced with redundancy.

If the Government policies for liberalising trade are successful in overcoming the almost annual economic crises, the pattern of defence spending will become more stabilized and the aircraft industry will be able to plan on a longer term pattern also. The link-up with Europe will also result in great collaboration with the developing European aviation industries and a strengthening of the NATO bloc, which in its turn will provide a more stable economic atmosphere.

It is perhaps unfortunate that Farnborough this year may tend to accentuate the gap that exists between the last generation of aircraft and the appearance of the new projects "in the flesh." It can be argued with reason that this is yet further evidence of the after-effects of the 1957 White Paper on the industry as a whole. Commercial prospects are always brightest when the buyer can actually see and test the wares rather than rely upon the information in a brochure. For this reason it would be more logical to regard the Twenty-second SBAC Show as the shape of things to come from a regrouped and more powerful industry, rather than as a measure of its current potential. ⟷

The Blackburn *Buccaneer*, the low level strike and reconnaissance aircraft which has been ordered into production for the Royal Navy. The aircraft is to be fitted with a weapons radar system developed by Ferranti Ltd. for the launching of bombs and rockets.

Final assembly of the **Lightning** at the English Electric factory. The last stage in the production will be the flight test at the manufacturers airfield at Warton.



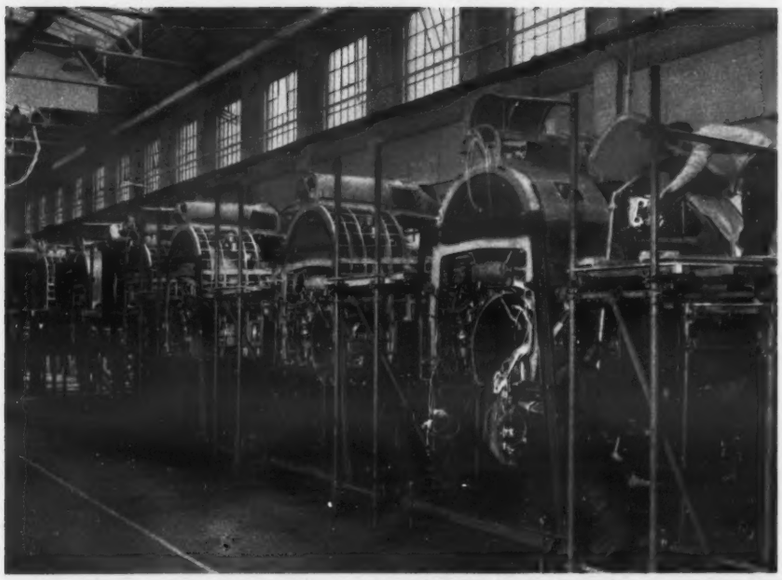
The wing sections in the process of being joined together prior to fitting to the main fuselage.

Production of a manned interceptor

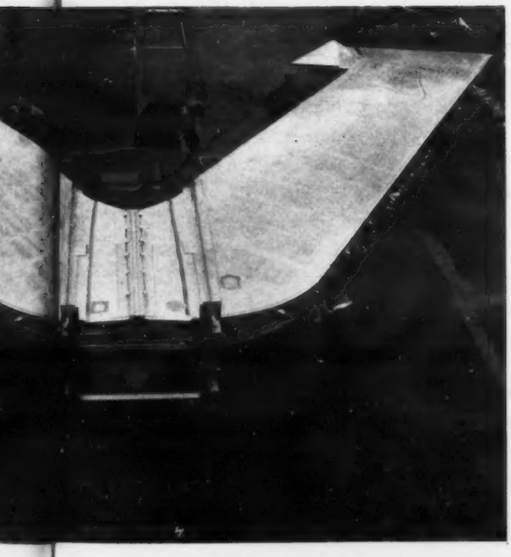
The Lightning assembly line at Warton

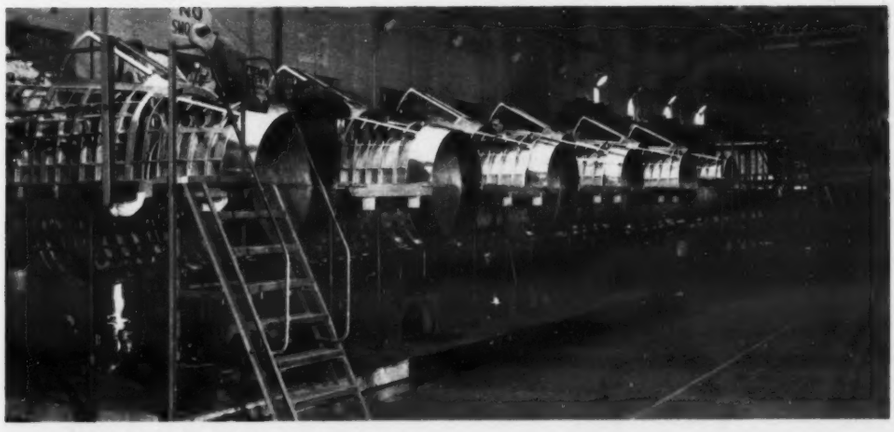
The two seat Trainer version on the production line. Equipment is being installed in the cockpit and front fuselage prior to engine installation.

At this point in the production line the wings and fuselage are mated together. The wings are joined as a single unit before being fitted.



Assembly of the centre fuselage sections of the **Lightning.** The British Aircraft Corporation, of which English Electric is part, say that the production of the aircraft is the most extensive and advanced programme ever carried out by the British aircraft industry.





Equipment installation and test in the front fuselage.

The **Lightning** in squadron service with the Royal Air Force. The tiger's head is the badge of 74 Squadron.

Electrical and mechanical equipment being installed and tested in the front fuselage section.

The BAC One-Eleven

By N. A. Barfield, Civil Aircraft Development Engineer, Vickers-Armstrongs (A|C) Ltd.

A feature of the *One-Eleven* is the ventral door with built-in steps. Another hydraulically operated door is fitted on the port side of the aircraft forward. This installation makes the aircraft independent of airport passenger handling facilities, which is a considerable advantage when operating through small and ill-equipped airfields.

The British Aircraft Corporation was formed during the first half of 1960 by the integration of the aircraft and guided weapons interests of Vickers-Armstrongs, Bristol Aeroplane Co., and English Electric, and by the subsequent acquisition of a controlling interest in Hunting Aircraft. On May 9th, 1961, the Corporation publicly announced its first new aircraft—the BAC *One-Eleven*. Vickers and English Electric were already in close collaboration before the formal merger, in the design and production of the TSR 2 tactical supersonic bomber for the RAF, while the integration of the wide civil experience of Vickers, Bristol and Hunting formed a powerful force for continuation of the penetration of world markets by British turbine powered airliners.

The *One-Eleven* had its genesis in a series of projects by Hunting Aircraft. The original aim was to provide a successor to their *Prince|Pembroke|President* series of light twin-engined transports. The main problem was to design an aircraft large enough to be economical as an airliner and yet not too large or complex for Hunting's limited capacity. Through a progression of projects, a basic philosophy had been formulated by May 1956, which has remained in principle as the theme of all subsequent projects culminating in the *One-Eleven*. This was a twin-jet aircraft with rear fuselage engine location, modest (20°) sweepback and all-round engineering simplicity for low capital cost. The designation of this aircraft was the Hunting 107. The aim was to produce a low-operating cost jet of modern concept for the short range routes hitherto served by propeller driven equipment. The Bristol Siddeley *Orpheus* was, at that time, the only suitable engine available.

Serious design work began in November 1957. A mock-up was built and low speed wind tunnel tests were completed. In April 1958, Hunting became part of Airco, a consortium set up by de Havilland to build the DH 121 *Trident*. The Hunting design effort was transferred from the twin jet 107 to the *Trident* but the 107 was kept up-to-date as a project.

In September 1958, it was realised that two turbofan engines, then being developed, would be more suitable for use in a short-haul airliner than the straight jets previously considered; providing a combination of turboprop economy and pure jet performance. The 107 was, therefore, redesigned around two Bristol Siddeley BS 75 turbofan engines. At this stage it was a 48-seater with a range of up to a thousand miles.

An artist's impression of the BAC *One-Eleven* short-range airliner, powered by two Rolls-Royce *Spey* by-pass engines.

Hunting Aircraft joined BAC during 1960, and all concerned recognised the value of the 107 concept. With its rear-engined layout it found ready acceptance by Vickers with the VC.10, and the range of rear-engined projects of both Vickers and Bristol.

The project went forward from this moment as a joint British Aircraft Corporation effort and immediately began to benefit from the combined design experience of the member companies. Steps were also taken to ensure the maximum utilisation of Vickers' vast range of *Viscount* operational experience.

Several important engineering changes were made at this stage. It was decided to widen the fuselage to accomodate 5-abreast seating as in the *Viscount*, instead of 4 as in the original Hunting design, and the position of the tailplane was moved from the middle to the top of the fin, as on the VC.10.

In August 1960 there was a presentation at Weybridge in which features of the project in revised form were set out before members of the Sales and Technical Sales Departments of Bristol, Hunting, and Vickers. This was immediately followed by exploratory sales visits to major airlines all over the world.

These visits were made by a number of British Aircraft Corporation teams and had two main objects (1) to assess the airlines' interest in a twin-jet airliner in the *Viscount|Convair* size bracket, and (2) to obtain airline reaction to the engineering and operational features of the aeroplane. Details of the 107, as presented to the airlines at this time, were

also displayed at the Farnborough Show in September 1960.

Reactions to the world sales tour were favourable and, in the last quarter of 1960, British Aircraft Corporation design teams synthesised the results and began to scheme the aircraft in greater detail. A number of changes were made as a result of airline reactions, including a switch from pneumatics to a conventional hydraulic system, the introduction of a ventral passenger entry and VC.10 type close-pitch windows (two per seat row). The fuselage cross-section was changed from circular to double-bubble form to meet a requirement for increased freight and baggage capacity. (A circular, though larger, cross-section was re-adopted in April 1961).

At the beginning of 1961, as a result of continuous liaison with a number of firmly interested airlines, it was becoming apparent that there were, in fact, two divergent requirements for short-haul twin-jet airliners. One group of potential customers accepted the 107 virtually as it stood, and placed maximum emphasis on simplicity and low capital cost. The other group liked the concept of the aircraft but required improvements in performance, payload and equipment standards, which would not have been possible within the time scale offered with BS 75 engines. This latter group of airlines placed greater emphasis than the first group on early delivery and together represented potential orders for a larger number of aircraft.

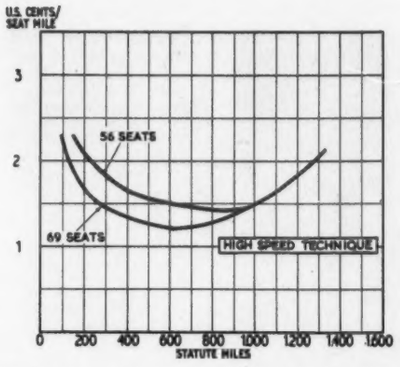
The possibility was therefore explored of installing the more powerful Rolls-Royce *Spey* engines, as already adopted for first flight in the *Trident* at the end of 1961.

In March, the twin *Spey* version was designated BAC *One-Eleven,* and a technical meeting was held at Luton at which agreement was reached on over 50 basic points to be embodied in the design. In mid-March, following a British Aircraft Corporation Board Meeting, Sir George Edwards set up an organisation within the British Aircraft Corporation to spread the overall task of designing, developing, building, and selling the twin-jet design powered initially with *Spey* engines, and an alternative with BS 75 engines to be available approximately one year later.

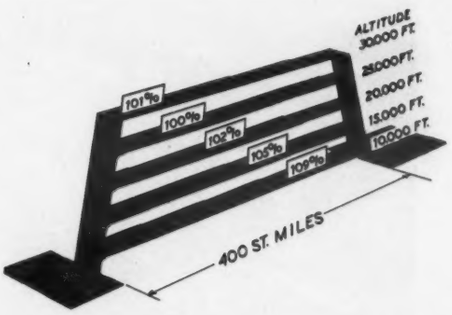
The Board's decision to proceed with these projects and to begin immediate production of an initial batch of twenty *One-Eleven* aircraft was stated at a sales conference at Weybridge in mid-April, attended by over sixty members of the Bristol, Hunting, and Vickers organizations. This decision had been made known to the Government in the previous month.

The sales campaign was made public at a press conference in London on May 9th, when the first order was simultaneously announced. This was placed by British United Airways and was for 10 BAC *One-Elevens* with an option on another five. Other airlines publicly declared their interest in the aircraft.

Rapid progress has since been made in order to achieve the stringent programmes laid down for design, development, flight test and production, which call for first flight in the 2nd quarter of 1963, initial deliveries to B.U.A. in the last quarter of 1964 and quantity production in early 1965. Central control of the project is through a small project team at Weybridge. The majority of the detailed engineering is being handled by Vickers (Hurn), Bristol (Bourne-

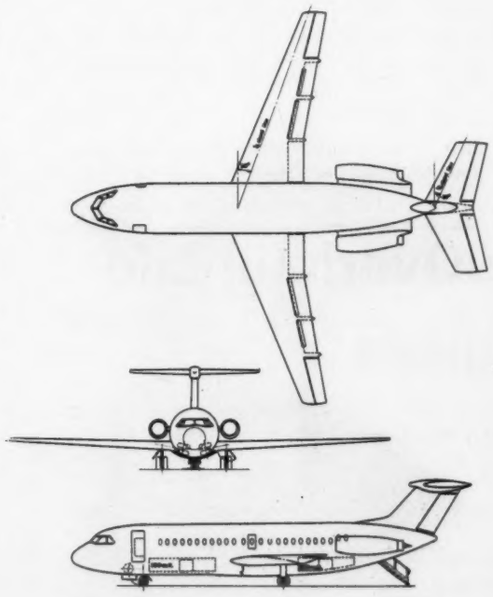


The direct cost per seat mile over various stage lengths. The costing method employed envisaged a depreciation of 10 percent per annum over seven years, fuel costs of 14.5 cents per US gallon and an annual utilization of 3,000 hours.



The diagram illustrates the flexibility of the One-Eleven in operation. The percentages indicate the variation of cost with changes in cruise altitude. The ideal altitude is shown as being 25,000 feet.

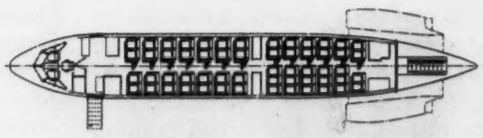
Technical data — BAC One-Eleven



Dimensions	
Length	93′ 8″
Wing span	88′ 6″
Wing area	980 sq. ft.
Aspect ratio	8
Wing sweep on ¼ chord	20°
Wheel track (shock absorber centres)	14′ 3″
Total accommodational length	58′ 9″
Interior height	6′ 6″
Interior width	124″
Capacities	
Fuel capacity (8 lb.per Imp.gall)	18,000 lb.
Freight volume	500 cu.ft.
Weights	
Maximum Ramp Weight	68,550 lb.
Maximum Take-off Weight	68,250 lb.*
Maximum Landing Weight	65,000 lb.
Typical Maximum Payload	14,000 lb.
Powerplants	
Engines	2 × Rolls-Royce RB.163-1 *Spey* Engines
S.L. Static Thrust	10,400 lb. Nominal Each.

* 73,500 lb. Optional Long Range Version.

Three-view drawing of the BAC *One-Eleven.* Accommodation is for up to 69 passengers and 500 cu.ft of baggage space is available.



Two proposed seating plans for the *One-Eleven.* Capacity ranges from 56 in the first class version to 69 in the economy class.

This view of the interior of the mock-up shows the space available within the cabin. With economy class, five-abreast seating the capacity is 69. The close pitch window arrangement gives two windows per seat row for maximum visibility.

The chief test pilot of the British Aircraft Corporation, G. R. Bryce, checking the flight deck layout in the mock-up of the *One-Eleven*.

mouth) and Hunting Aircraft (Luton). Final assembly will be at Hurn, flight testing being controlled from Wisley.

The customer mock-up at Weybridge is largely complete, engineering mock-ups are proceeding apace at the various design establishments and engineering drawings are already being released to the production departments.

The aircraft now being offered to airlines has a gross weight of 68,250 lb with an optional long range version at 73,500 lb. With normal reserves, the ranges with a full payload of 14,000 lb (typical layouts range from 56 first class to 69 tourist) are 700 and 1,100 statute miles respectively. The latter version is, in fact, that chosen by B.U.A. to meet their London/Malta requirement. The *One-Eleven* is capable of using 5-6,000-ft airfields without serious airworthiness or noise problems. It is offered as "The jet successor to the *Viscount* with even better than *Viscount* economics." This claim is made possible by its high cruise speed of 540 m.p.h. (and hence low block times and high productivity), modest fuel loads and all the features necessary for high-intensity short-haul operation including a high landing weight, structural ruggedness, systems simplicity and self sufficiency (APU), and interior flexibility.

As stated at the press conference, the selling price (fixed until mid-1965) is in the neighbourhood of £ 775,000 or just over $ 2 million. These factors in combination make the *One-Eleven* an ideal *Viscount* successor and a natural growth aeroplane for Convair and DC.3 operators. It is aimed to bring low operating cost jet travel and comfort standards to the short range routes of the world, covering both the high frequency and commuter duties of larger operators and the lower frequency regional services of smaller operators, hitherto operated by propeller driven equipment. ◆◆

Extending the Overhaul Life of Turbine Engines

By A. G. Bowling, Chief Service Engineer, Aero Engine Division, Rolls-Royce Limited

Rolls-Royce turbine engines have established record overhaul lives in airline service. At the time of writing in early July, the overhaul life of the *Dart* turboprop, the first turbine engine to enter widespread commercial service, is 3,200 hours. *Avon 542* turbojets in the *Comet 4* have just been approved by the Air Registration Board to run to 2,900 hours between overhauls and *Avon 527s* in the *Caravelle* run to 1,600 hours. *Conway 509* by-pass engines, which power Boeing 707s and Douglas DC-8s, are running to 1,600 hours and one operator has now been granted 1,800 hours between overhauls. No work is necessary on any of these engines between overhauls except normal maintenance checks, which involve nothing more complicated than filter inspections and routine ground running.

Although these outstanding overhaul lives have justified the early claims made for the turbine engine, they have not been achieved without much hard work and development during the past decade. Over this period, operating experience with Rolls-Royce turbine engines has increased from less than a million to nearly 30 million hours *(Fig. 1)*. The progress made is illustrated by surveying experience with the *Dart*, *Avon* and *Conway*. It is still too early to examine progress with the *Tyne* turboprop in detail, but engines have been examined at 400 hours and are being run on a trial basis to 500 and 600 hours between overhauls.

The Dart Turboprop

The *Dart* turboprop went into airline service in 1953 with an initial overhaul life of 400 hours. The *Dart* was the first gas turbine engine to go into extensive commercial service and everyone, including the airworthiness authorities, was very cautious.

Several troubles were encountered in the early days and modifications were embodied in the field to overcome failures in the reduction-gear bearings and the torquemeter pump driving gear. Overhaul life development really started when these early problems had been solved. The first life-limiting item was the flame tube, which buckled and cracked very extensively. This led to a pause at an overhaul life of about 750 hours while cures were developed, manufactured, and fed into the engines which were in service.

As shown in *Fig. 2*, it took some 18 months to establish an overhaul life of 1,000 hours. Despite early difficulties, there were few in-flight shut-downs with the *Dart* even at this stage and most of the troubles were found on filter inspections.

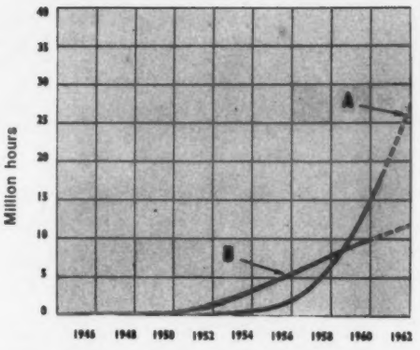
Apart from the items mentioned and a restriction on the first-stage impeller, no serious life-limiting items were encountered. Since the introduction of separate cooling rings on the flame tubes, there has not been a major life-limiting factor on the *Dart* engine up to the current maximum life of 3,200 hours between overhauls.

Based on this experience, the rate of overhaul life development of the later three-stage turbine engines was much quicker than that achieved on the earlier engines, as *Fig. 2* also shows. This was partly due to the design lessons learnt and partly to the confidence of the airworthiness authorities in the engine type and in turbine engines in general.

Dart engines have now flown nearly 16 million hours and have an excellent in-flight shut-down record. On average, only one shut-down has occurred for every 20,000 hours flown. At the same time, increases in overhaul life have not been accompanied by an increase in parts cost. In fact, the parts cost has fallen from $3.7 per hour in 1956 when overhaul life was 1,400 hours, to $2.47 per hour in 1960 when the life was 3,000 hours.

The Avon Turbojet

At the start of commercial operation, the *Avon* engine had a background of just over two million hours in military service. Useful though this was, earlier experience with the *Derwent* and the *Dart* had shown that such military experience was only of limited value in establishing a civil engine, because components in military engines ran to only relatively short maximum lives. For this reason a route-proving exercise was carried out by BOAC with the *Avon*-engined *Comet 2E*. The first engines to be removed at 250 hours were in such good condition that the remainder were allowed to run on to 500, 750 and 1,000 hours. As a result, commercial passenger-carrying operations began with an engine overhaul life of 1,000 hours, and



The growth of operating experience with Rolls-Royce turbine engines over the past decade. The curve "A" indicates the hours accumulated by civil engines in airline service, while curve "B" refers to the operation of military engines. In both cases the curves have been continued on the dotted lines to indicate the anticipated totals in 1962 *(Fig. 1)*.

Fig. 2, shows the rate at which the *Avon* overhaul life has increased over the years until it now stands at 2,900 hours.

The life development of the *Avon* in the *Caravelle* was somewhat slower because several operators converted the engines to a higher rating at an early stage; this held the overhaul life to 1,200 hours for some months. However, the life development programme is now again under way and engines are already being trial-run to 1,800 and 1,900 hours. Civil *Avons* have now flown nearly 1,100,000 hours in commercial service.

Again, a significant feature of civil *Avon* operation has been the very low rate of in-flight shut downs (23,316 engine hours per shut-down). Experience with turbine engines had shown that about 80% of unscheduled engine removals are made at base. This is undoubtedly because the jet engine will continue flying safely until a filter inspection or an external examination shows that the engine should be removed because there are early indications of a failure.

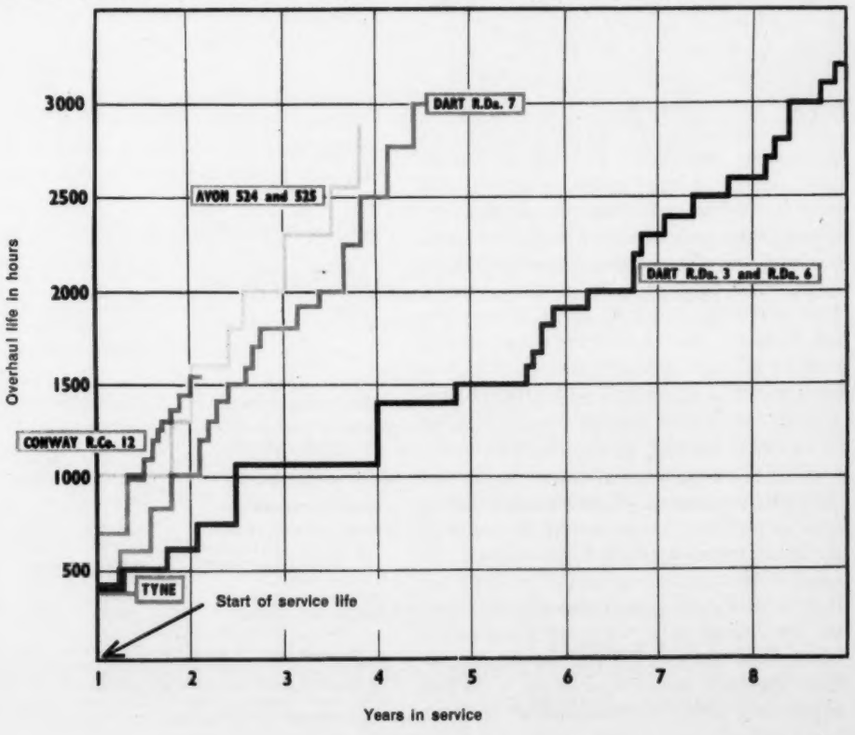
The Conway By-pass engine

Fig. 2 shows the rate of overhaul life development for the *Conway* by-pass engine during about 18 months of service operation. The early troubles with this engine are now well on the way to being completely cured, in most cases by minor changes, either in operational technique or engine build. The overall rate of power shut-downs in flight for Boeing 707 operators stands at one per 9,000 hours and for all operators at one per 6,000 hours. Commercial running time with the *Conway* is now approaching 400,000 hours.

Rate of overhaul life development

The rate of increase in engine overhaul life depends to some extent on the rules followed by the airworthiness authorities concerned. In the early days of the *Dart* it was the practice in the UK for the starting life to be very low and to be increased by small steps of 100 hours on a one-per-aircraft trial basis. This may be justified during the early life of a

A progress report on the increase of overhaul life for various engines. At the left of the graph is the overhaul life in hours and at the bottom the number of years the engines have been in service. The cumulative effect of experience gained in operations is illustrated by comparing the progress of the *Avon* to 2,900 hours in less than four years operation, while the older engine, the *Dart*, required over eight years to attain the same overhaul life *(Fig. 2)*.



turbine engine, but once the engine is shown to be basically sound, the rate of life development can be increased. This can be done both by larger increases in overhaul life and also by reducing the number of engines which must be seen at each step.

It has now become general practice outside the USA to allow overhaul life increases of up to 300 hours at a time, with inspection of six engines at each step, or alternatively increases of 100 hours with inspections of two engines at each step. Depending on the type of operation and the stagger of engine hours in the fleet, either of these methods allows a rapid increase in overhaul life to be achieved on an engine with a low in-flight shut-down rate, and providing a good strip examination. This philosophy, however is not universal and some authorities have drawn up rules to align overhaul life development with in-flight shut-down rate alone.

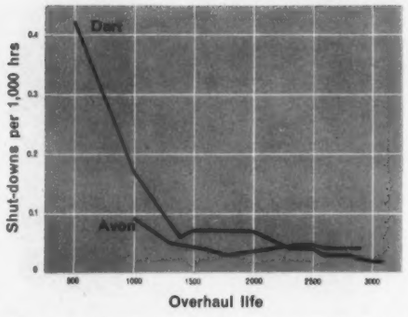
The *Dart* has an overhaul life of over 3,000 hours and the *Avon* is just approaching 3,000 hours. Experience with these engines has shown that the in-flight shut-down rate has been almost independent of the actual overhaul life at any given time. *Fig. 3* shows this relationship for the *Dart* and *Avon 542*.

When a new operator commences operations with a proven engine, the rate of life development can be much quicker if established operational techniques are used, and engine condition at overhaul is similar to that previously experienced. For example, a new operator of a *Dart* engine would have an initial overhaul life of 2,250 hours, a new *Avon Comet* operator a starting life of 2,000 hours, and an *Avon Caravelle* operator 1,400 hours.

It has been clearly demonstrated that the stage length, operational techniques, and aircraft installation, greatly affect the condition of engines at overhaul and hence the rate of life development and the maximum overhaul life which is likely to be achieved.

This highlights the important effect of short-range operations. Rolls-Royce engines have pioneered short-range operation with both turboprop and turboprop engines. The average stage time with the *Conway* is 6 hours but with the *Avon* in the *Caravelle* it is 1.5 hours. The average stage time for major *Dart* operators is only 60 to 70 minutes and one operator has an average stage time of only 24 minutes. The reliability of the *Avon* compares very favourably with other engines whether compared on the basis of hours flown or the number of takeoffs completed.

It has not been found necessary to embark on a long programme of maintenance inspections or part-life changes during the overhaul life development of Rolls-Royce engines. To avoid restricting the overhaul life, it has from time to time been found necessary to schedule the change of a particular troublesome component temporarily. But we do not believe that any particular part of a turbine engine will always have a shorter life than



In-flight shut-downs per 1,000 hours plotted against achieved overhaul life for the *Dart* and the *Avon* engines. The curves show the shut-down rate to be largely independent of overhaul life.

the rest. In one engine type it may be the compressor, in another the turbine, or combustion system or reduction gear.

In addition, no oil changes are necessary on Rolls-Royce engines between overhauls. This is an important economic point owing to the relatively high cost of turbine engine oils. Oil consumptions in service have been found to be only 0.06 pints per hour for the *Dart*, and 0.25 and 0.4 pints per hour respectively for the *Avon* and *Conway*.

Component Lives

When operating engines to long overhaul lives, major components will eventually reach a life limit and it may then be necessary to fit this in with various multiples of the overhaul life.

A long and reliable overhaul life is an obvious advantage in reducing maintenance and overhaul costs. The work carried out on most engine parts at overhaul will be little different whether the life is long or short. Experience has indicated how far it is possible to relax acceptance standards once the condition of the first engines has been assessed. But it must be recognised that inspection techniques on certain major components must become increasingly stringent as overhaul life is extended.

The clearance of major components to long lives is very important for the successful operation of a civil turbine engine. Lives in excess of those on service engines are cleared by testing at Rolls-Royce, so that the operator does not have to establish lives for himself in service. Much engineering effort has been put into reproducing service conditions so that the life remaining in these parts can be quickly assessed; much has been achieved but much remains to be done. For example, it has been found a false economy to refit main ball and roller bearings for a second and third life until an appreciable number have been seen after the first overhaul life, and found to be in good condition. The secondary damage resulting from a bearing failure can be far more expensive than the cost of rejecting a few bearings.

On many other parts which last more than 8,000 hours, a natural stagger in hours develops over a period of years. If trouble does eventually occur and a maximum life has to be imposed, this can be handled satisfactorily at overhaul. The table shows the lives achieved with the main components in the *Dart, Avon* and *Conway*.

This brings us to consideration of failure indicators. It is essential that such devices should be more reliable than the engine itself. This does not yet apply to the vibration meter, which is potentially one of the most useful devices. With experience, this instrument may become vital to the running of engines for long lives, but it is possible that it should be used as a checking instrument on the ground rather than as a flight instrument. Magnetic plugs in the oil system have been shown to be invaluable in picking up early indications of bearing and other failures; they can thus help to avoid in-flight shut-downs.

I believe that the engine manufacturer should resist the continual pressure to fit more and more devices for in-flight checks by the pilot. The engine must be reliable during flight. Detection devices can be used by an operator to spot an engine failure in its early stages, but these devices should be limited to ground use unless they are essential to prevent an in-flight failure which might endanger the aircraft.

It will probably not be advisable to extend the overhaul life of engines indefinitely. At present the engines with long overhaul lives remain installed in aircraft for months on end, over a year in many cases. For this reason the practical limit for overhaul life development may be reached between 3,000 and 4,000 hours.

Many lessons have been learned, in developing Rolls-Royce turbine engines to run long overhaul lives. These have led to improved design and engineering techniques which are being incorporated in the latest Rolls-Royce by-pass engine, the *Spey* which is to be installed in the de Havilland *Trident* and BAC *One-Eleven* airliners. In consequence the future costs of short and medium-distance air travel should be significantly reduced. ←

Long-Life Components

Component	Life in hours up to which parts have been inspected		
	Dart	Avon	Conway
Low Temperature			
Propeller shaft and annulus gear	14,000	—	—
Main engine casings	14,000	6,333	2,600
Axial compressor assembly	—	6,333	2,600
Main compressor shaft	12,500	6,333	2,600
High Temperature			
Flame tubes	9,000	2,900	2,600
H.P. nozzle guide vanes	7,000	6,333	2,600
L.P. nozzle guide vanes	9,000	6,333	2,600
Turbine discs	10,000	5,376	2,600
H.P. turbine blades	6,500	5,361	2,600
L.P. turbine blades	12,000	5,361	2,600

In all cases none of these are ultimate lives; the majority of these parts have been refitted for an additional 3,000 hours in the case of the *Dart* and *Avon* and 2,000 for the *Conway*. This does not apply to *Dart* turbine discs at the present time although further increases are likely later on.

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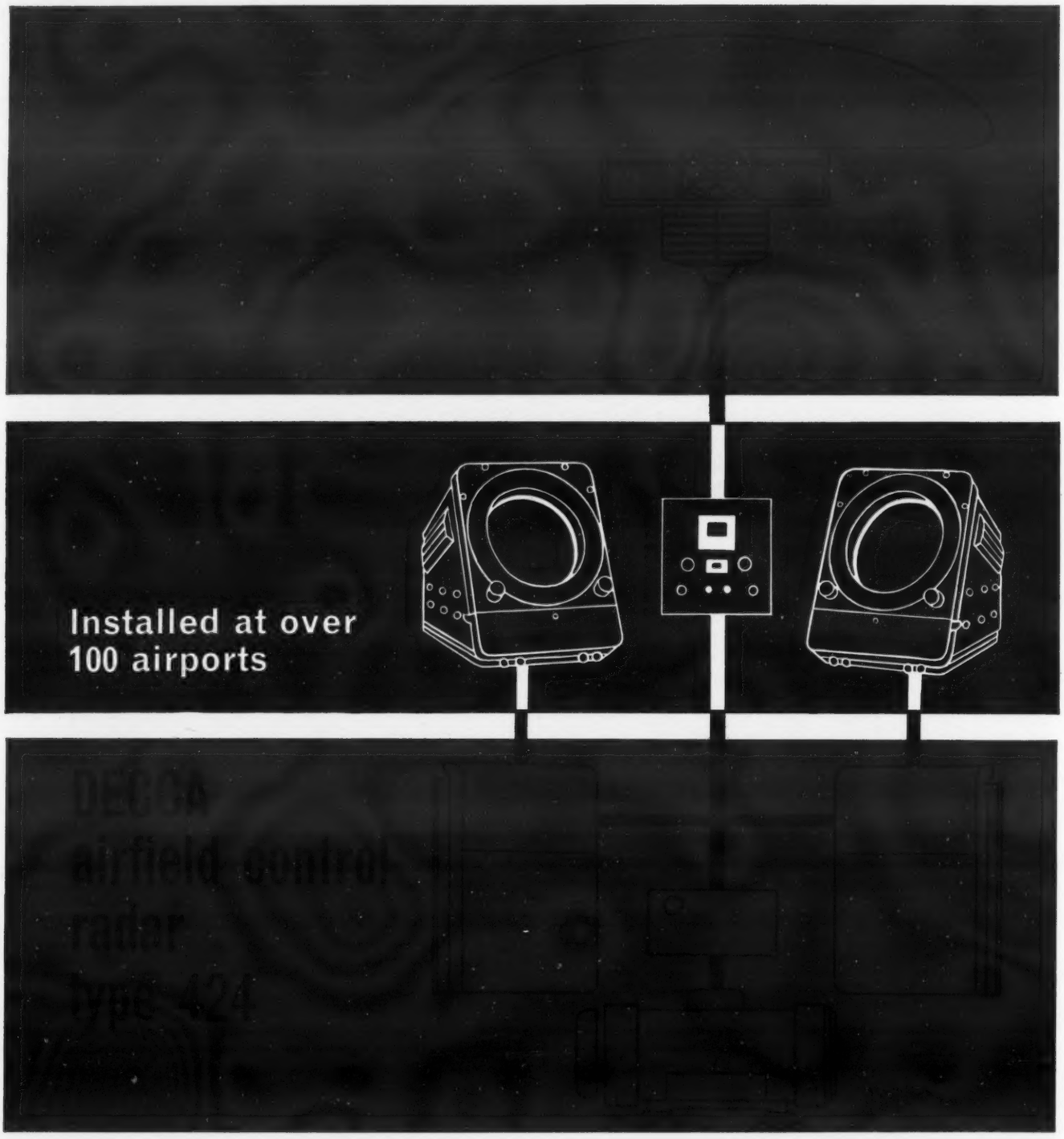

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The Development of High Temperature Materials

By E. R. Gadd, Chief Metallurgist and Assistant Chief Engineer, Bristol Siddeley Engines Ltd.

It has been said of the turbine engine that " if you can make the turbine blades work, you can make the engine work."

This statement, like many similar generalizations, is no doubt an oversimplification of turbine engine problems. However, it is certain that much of the rapid progress in turbine engine performance has been due to intensive research into blade materials and into techniques of blade manufacture.

Bristol Siddeley Engines recognized this from the early days, and it is significant that when the technique of precision casting was introduced to this country from America during the latter part of the Second World War, the potentialities of this process for turbine engine components were immediately recognized, and Bristol was one of the first companies in the country to lay down a precision foundry. This foundry was specifically designed to produce turbine blades in quantity. Shortly afterwards it was also decided to install a forging shop to produce either oversize or precision forged turbine and compressor blades. These facilities became a great asset to the Company in that it was able to take early advantage of any new material developments, whether in the cast or wrought form.

In addition to the casting and forging of blades, the Company's machine shops were fully equipped to machine blades from oversize forgings or from bar stock, and in fact many blades now produced are machined from rectangular or rhomboidal shaped bars.

The precision foundry (now one of the most advanced in Europe) made some experimental sets of Nimonic 80 turbine rotor blades as far back as 1943. This was a very bold experiment for those days and, in the light of our present knowledge, it is not surprising that they were not altogether successful.

The Nimonics were not considered good casting alloys but Bristol Siddeley soon learnt to make good stator segment castings in Nimonic 80 and Nimonic 90. More recently, alloys such as X 40 and W.I. 52 have tended to replace the Nimonics for the hotter stator stages.

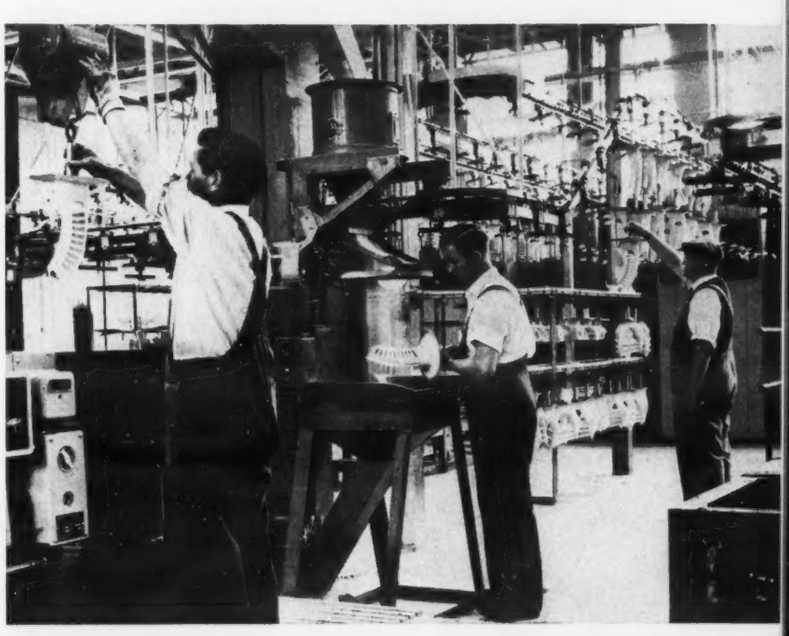
The early attempts to produce turbine rotor blades by casting were unsuccessful, mainly owing to the difficulty of maintaining the high standard of cleanness and freedom from defects that these blades demanded. There was, moreover, a steady and constant improvement in wrought blade materials and at that stage cast blades gave no technical advantage over the wrought versions.

However, the idea that at some stage the cast rotor blade might well come into its own was always kept in mind, and in 1955 a number of sets of X 40 rotor blades were cast and engine tested for comparison with wrought Nimonic 90. This experiment showed that, while X 40 gave somewhat superior results to Nimonic 90, the improvement was not sufficient to justify introducing X 40 into production, and in any case other wrought alloys (i.e., Nimonic 100 and later Nimonic 105) became available. The X 40 exercise was, however, very valuable in that it showed that, although it was air cast, this material was extremely consistent in its behaviour in the engine and superior in consistency to the wrought alloys.

The development of the wrought alloys Nimonic 100 and Nimonic 105 revealed the increasing difficulty in forging that was to be expected from improved strength, and it became apparent that any future alloys would need new ingot casting techniques, since the alloying additions required for these improved alloys were expected to produce a much lower level of cleanness. With the advent of industrial scale vacuum melting techniques, however, nickel base alloys took a new step forward in the high temperature field.

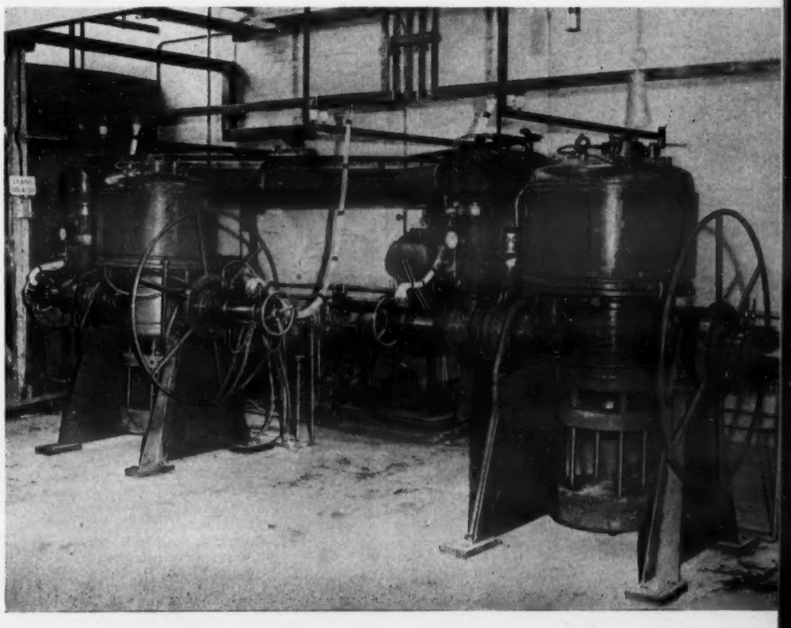
Difficulties in producing sound ingots for forging purposes were reduced because the metals were free from dissolved gases, inclusions, and undesirable low melting point impurities. In the wrought field the alloys Nimonic 115 and G 70 appeared with improved properties over Nimonic 105 but with the attendant blade forging difficulties which were inevitable with the higher hot strength.

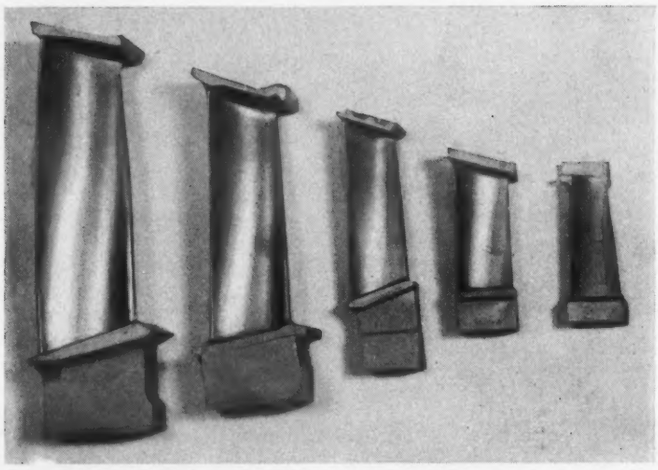
The real advance, however, came with the development of alloys suitable for cast blades. The Company was quick to realize the



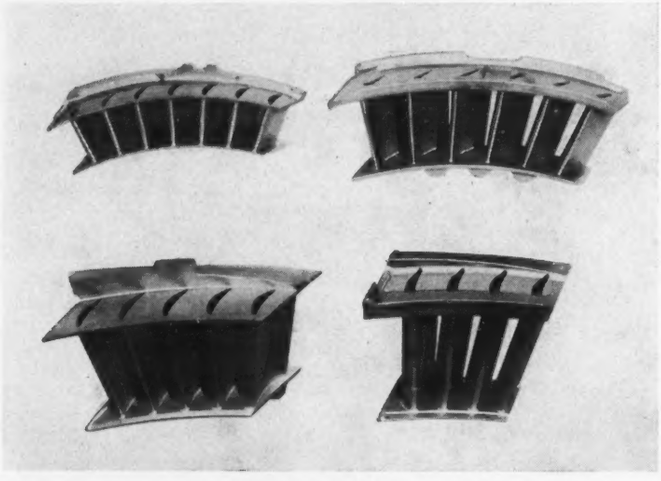
A stage in the moulding process of stator segments in the foundry. The production has been extensively mechanised and the components can be seen in transit to the next operation on the overhead conveyor.

Two of the vacuum casting furnaces which are used for the production of blade castings in G.64 and later alloys. Large numbers of turbine rotor blades in G.64 have been produced by this method for the *Proteus*.





Examples of blades which have been produced by vacuum melting and casting techniques. Development work is continuing on new alloys such as the cast cobalt G.34.



Hollow stator blade segments as received from the foundry in the "as-cast" condition. The production of cooling channels in the blades during the casting process is simpler than drilling and welding methods.

importance of this and promptly ordered a vacuum high frequency furnace for the foundry, and put in hand modifications to the existing carbon arc furnaces to make them adaptable to vacuum casting techniques.

One of the first truly successful vacuum melted and vacuum cast alloys was G 64, which led the current wrought alloys by some 35°C and which was shown both on engine test and production approval stress-to-rupture test to give extremely consistent performance. *Proteus* turbine rotor blades in G 64 have been produced in large quantities over the last few years and have fully met the performance predicted from engine development tests and laboratory evaluation.

Whilst these cast blades in vacuum melted G 64 are giving satisfactory air line service, foundry development work continues on newer and better alloys such as E P K 24 and G 74, which are substantially in advance of any wrought alloy so far submitted.

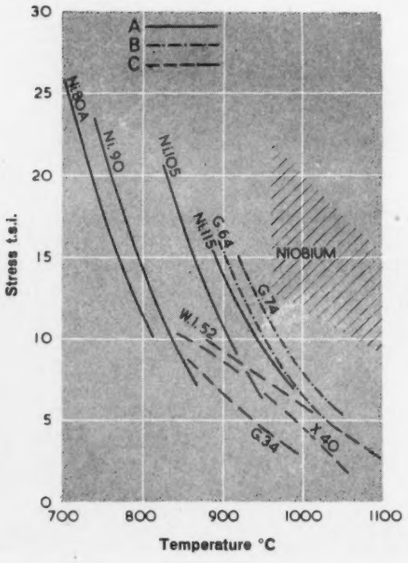
In addition to high creep strength, a high resistance to oxidation is an essential requirement for a successful gas turbine blade material. The difficulty of combining these properties in the same alloy was appreciated by Bristol Siddeley, and a research programme on surface coatings has been in operation for the last five years. This work proved to be well justified since it was found that G 64, with a chromium content of 11.0 percent benefited considerably from an aluminium coating; in fact even alloys with chromium contents in the 14/16 percent region are improved in their resistance to oxidation, especially a vicious form of oxidation which is activated by the presence of sulphates.

While the exploration of new and better alloys for blades is carried on without respite, due regard has been given to methods of cooling blades and, in particular, ways of producing cooling holes or passages in blade forms. There are many ways of forming these holes or passages. They include conventional drilling, spark machining, electrolytic drilling, joining of split sections by high temperature brazing and by welding by various methods, including electron beam welding. In the case of cast blades, the production of holes during the casting process itself offers a much more straightforward manufacturing process.

From the point of view of overall engine performance it is clearly preferable to utilize a superior material rather than be compelled to produce holes or passages in an inferior one. The production of blades from stock material which has been drilled and subsequently extruded to produce special hole shapes has also been explored. All these methods call for very difficult and costly manufacturing techniques.

From the manufacturing point of view, there is no question as to the advantages of using a solid blade having the right order of hot strength. In the search for better blade alloys, the Bristol Siddeley research team are looking beyond the nickel base alloys to chromium and niobium.

It is believed that the next real step forward may well lie with niobium. The development of niobium alloys is likely to be a long and costly business and will involve further intensive work in the field of surface coatings. This adventure into new and exciting materials is but a continuation of the policy which has been followed by the Bristol Siddeley Company from the time of the development of its first turbine engine; a policy dictated by the conviction that the future of this type of power unit is dependent to a very great extent on successful development of improved turbine blade materials. ◂◂

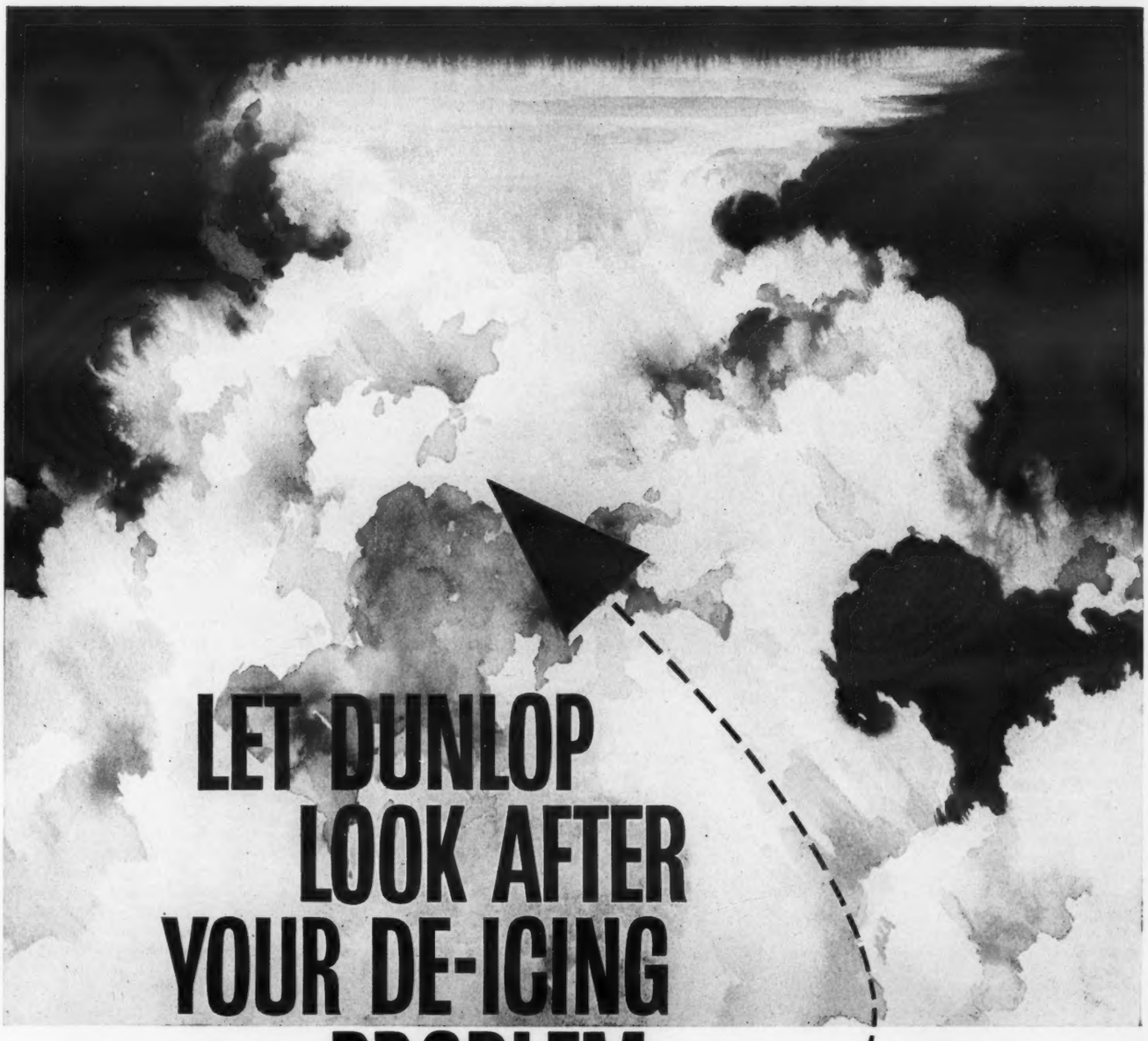


A comparison of the stress rupture properties of various turbine blade materials.
A: wrought nickel alloys
B: cast nickel alloys
C: cast cobalt alloys
The shaded area of the diagram indicates the current development of niobium alloy.

The composition of a number of high temperature alloys

ALLOY	C	Cr	Al	Ti	Co	Mo	W	Nb	V	Ni
Ni 80A	0.05	20.0	1.0	2.3	—	—	—	—	—	R
Ni 90	0.08	20.0	1.4	2.3	16.0	—	—	—	—	R
Ni 105	0.15	14.5	4.5	1.2	20.0	5.0	—	—	—	R
Ni 115	0.15	15.0	5.0	4.0	15.0	4.0	—	—	—	R
G 64	0.10	11.0	6.0	—	—	3.0	4.0	2.0	—	R
G 74	0.12	16.0	4.0	4.0	—	—	8.0	—	—	R
G 34	0.8	19.0	—	—	R	2.0	—	1.3	2.8	12.5
X 40	0.4	25.0	—	—	R	—	8.0	—	—	10.0
W.I.52	0.4	20.0	—	—	R	—	11.0	1.5	—	2.0

Key: C = Carbon; Cr = Chromium; Al = Aluminium; Ti = Titanium; Co = Cobalt; Mo = Molybdenum; W = Wolfram; Nb = Niobium; V = Vanadium; Ni = Nickel; R = Remainder.



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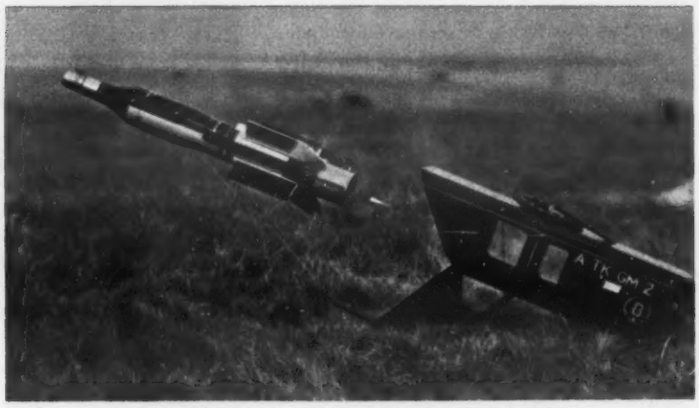
The Vickers Vigilant

A One-man Anti-tank Weapon

By Lieut. Colonel H.Lacy, M.B.E., B.Sc.,
Vickers-Armstrongs (Aircraft) Ltd.



The Vickers *Vigilant* anti-tank guided missile at the moment of launch. The guidance wire can be seen as it is stripped from its retaining cover on the underbody of the missile. The marker flame, which appears some little distance behind the missile, also assists in burning the by-products of the rocket motor combustion. In consequence, no smoke trail is left to mark the launch point to the enemy.

The battlefield has been more or less dominated by armour for some 45 years and, in the face of the present "nuclear stalemate," there is again growing emphasis on conventional armament. The accepted need for the rapid deployment of "fire brigade" forces with the capability of strong anti-tank defence points to a requirement for a light, portable, anti-tank weapon, which can be carried in quantity in an aircraft. Lightly armed forces, equipped with such weapons, can be air-transported into a "trouble spot" and maintain adequate defence against armour, pending the arrival of heavier reinforcements, possibly by slower transport.

To fulfil such a requirement, a small guided missile, which is simple in concept, light, and compact, is the obvious weapon. An efficient weapon of this type would redress the balance of power and enable lightly armed airborne forces to maintain their ground against enemy armour.

In 1950, Vickers-Armstrongs (Aircraft) Limited, now a member Company of the British Aircraft Corporation, entered the field of guided weapons, and in the following few years built up a team which acquired considerable experience in missile development, including air-to-ground, air-to-air, and ground-to-ground projects.

Early in 1957, a draft specification for a man-portable anti-tank guided weapon, such as to enable a soldier to "kill" single-handed the heaviest tank, was prepared, although there was, at that time, no stated requirement for an infantry anti-tank guided weapon.

The development of *Vigilant* (*VI*sually *G*uided *I*nfantry *L*ight *AN*ti-*T*ank missile) was initiated around this specification and, as it was a private venture project, user influence was brought to bear immediately by close liaison with the Army. The first control missiles were fired in September, 1958. By early 1960, after the firing of as few as 100 missiles during development, reliability was as high as 83 percent, and rose to the current level of 95 percent early this year. It was already very evident that the design interpretation of the concept was a sound one, primarily suited to equipping the infantry battalion for the first time with a weapon which could reach out and prevent armour from infiltrating into its area of influence.

Throughout development, it was considered more important to restrict the system weight to a one-man load than, for example, to strive for greater range, especially when Weapon Assessment War Games with armour revealed that 70 percent of the engagements were at ranges less than 1,100 yards.

Experience with other anti-tank guided weapons already under development emphasized the need for a very simple and easy-to-learn control system, and if it was to be an infantry weapon, it was more economical to incorporate an autopilot, than to attempt to train "pilots."

The salient parameters selected to control the design were:—

1. Arbitrary limit in size and weight, in order to maintain the truly "one-man" concept; no "black boxes" or ancillary gear.
2. An easy-to-learn control system, based on the assumption that the weapon could be operated with no special training, and therefore by all grades of soldiers.
3. The shortest possible time of flight, in order to obviate any threat of counter-measures.
4. The maximum possible size and weight of warhead. An inherent flexibility for shift of centre of gravity with additional warhead weight was provided for by adequate design tolerance in the aerodynamic performance of the missile.

The design response to these parameters is reflected in the following characteristics of *Vigilant*:—

1. The missile weight has been held down to 31 lb. There is no ancillary gear except a carry box launcher and a monocular sight.
2. The velocity control autopilot system has completely solved the training problem, and typical infantrymen, after simulator training only, have scored (including their training missiles):—

   Private A 12 hits out of 14 missiles
   Private B 10 hits out of 11 missiles
   Private C 7 hits out of 9 missiles

   Most of these hits were obtained against difficult moving targets.
3. The time of flight is 12 seconds out to 5,280 ft. The striking velocity of the missile is 500 f.p.s., which is twice as fast as any comparable missile and enables snap targets to be engaged at the longer ranges.
4. The warhead weight is 36 percent of the flying weight of the missile. It has an optimum lethality for a missile of this size and can kill the heaviest tank.

The engineering integrity of the design is reflected in the relatively small number of missiles fired during development, and the current high reliability figure.

Some Design Features

The very low aspect ratio wings are fitted with trailing edge flaps, operated by gas driven actuators responding to the controller's signal. The provision of electrically controlled gas-operated valves in the actuator system is an ingenious arrangement, whereby the gas piped from the rocket motor not only operates the valves in the actuators, but also drives a small turbo alternator which provides electrical supplies to the whole system, with no need for auxiliary batteries.

The gyroscope assembly for the autopilot consists of two gyroscopes, one for pitch and one for yaw. The technical advantages of *Vigilant* are principally focussed on its autopilot, with a closed loop velocity control system. The operator is required only to change the heading of the linear flight path missile on to the line of sight to the target, whereas in all the other anti-tank missiles of this type, which are acceleration-controlled, the operator is called upon to smooth a curvilinear flight path into a straight line of sight. Many other advantages accrue from the autopilot:—

(a) It provides a system which is easy to operate. Very few missiles are required for training.
(b) The chance of a hit is greatly increased. Accuracy is such that the vulnerable part of the tank can be hit.
(c) An unrivalled minimum range performance (600 ft) is achieved, as the missile can be rapidly brought on to the sight line.
(d) A wide angular coverage (± 40°) is practicable, with great flexibility at angle-off shots.
(e) The autopilot also arranges that the missile automatically levels out at a convenient height after launch, thus considerably easing the operator's task.
(f) The autopilot ensures that, should there be a disturbance in the flight of the missile due to a gust of wind or grazing of an obstruction, such as a bush, a change of attitude will result, and the missile will be immediately and automatically restored to its original heading, having been subjected only to a small lateral displacement, which the operator immediately observes and corrects.
(g) The autopilot also ensures that the missile is at all times automatically turned from the original launch heading towards enemy lines, thus minimising the risk to own troops.

Other advantages in the tactical handling of the weapon are derived from its high manoeuvreability and lethality. *Vigilant* has a maximum 7 g lateral manoeuvreability and can achieve a large body incidence. This contrasts with the aerodynamic control by spoilers of typical acceleration-control missiles, with manoeuvreability less

than 2 g. Their low incidence and low speed dictate the large wings, which make them cumbersome to handle, in addition to restricting performance potential.

The high velocity, and the consequent short time of flight, is a sensible compromise between the absolute minimum time required to hit a tank as soon as possible and the time necessary to enable the operator to get his missile under control. A *Vigilant* missile can hit a tank faster than a low velocity infantry gun—which has first to range—can put a shot against one.

The particularly large and heavy warhead for a weapon of this size, with its high chance of kill against the heaviest tank, shows a marked superiority over all other weapons when measured in terms of performance against total equipment weight and manpower. The warhead will defeat any known armour.

Tactical Employment

Vigilants in concealed forward positions enable the defence to reach out in range, and, in conjunction with properly sited anti-tank guns, provide powerful defence in depth. The tactical versatility of the weapon is well illustrated by the many roles arising from its portability and absence of ancillary equipment. In marine commando operations, the *Vigilant* gives invading troops, for the first time, the ability to engage instantly and effectively any armour contesting the landing.

In airborne operations, the paratrooper can drop with his *Vigilant* and engage enemy armour within seconds of landing. Heavy anti-tank guns, because of their bulky nature, must be dropped separately. The paratrooper may, on landing, be faced with the hazard of running a considerable distance, unloading the anti-tank gun, and then setting it up, before being able to engage the enemy. *Vigilant* affords valuable protection during the critical phase of derigging the heavy equipment drop, i.e. when the airborne forces are most vulnerable.

In association with the helicopter, the *Vigilant* can provide the Army with great flexibility in anti-tank operations. A helicopter, with rack-mounted missiles, could provide a very effective method of rapidly meeting and defeating suddenly developed and widely separated tank threats. Alternatively, troop-carrying helicopters could be used for the rapid transport of *Vigilant*-armed soldiers to otherwise inaccessible terrain favouring defence against attacking armour.

What the infantryman has always wanted is an effective weapon which can be carried by the leading troops in the attack. In *Vigilant*, the battalion commander will have a weapon which can reach out and prevent enemy tanks from infiltrating into his area of influence without his having to call on armour, which since the war has been the solution to this anti-tank problem. The "armour v. armour" battle of attrition is not only a costly means of killing tanks, but has serious tactical limitations. Supporting armour is not airportable, and will seldom—if ever—be available in the opening stages of a limited war. Moreover, armour is often separated from the infantry by obstacles, such as water, and must frequently be withdrawn from its forward area role for maintenance and concentration purposes.

A *Ferret* scout car with two *Vigilants* mounted on the turret. The car commander is holding the monocular sight and firing control used for the guidance of the missiles. A light scout car similarly equipped represents a serious threat to heavy armour.

An infantryman places the combined carry-box/launcher in position. The reel in the foreground carries the firing wire which is paid out to the concealed firing point. The operator can be positioned some distance from the launcher to command the field of fire.

Vigilant will not only give the infantryman a psychological balance against armour, but will force armoured forces to use ground where more orthodox weapons, properly sited and defiladed, can attack and kill.

Strategical Significance

The strategical significance of such a small weapon, weighing little more than the accepted commercial air-line baggage allowance (44 lb), is the anti-tank capability which can be packed into any type of aeroplane.

In the Bristol *Britannia 253*, in service with the Royal Air Force, 705 *Vigilants* could be stacked by means of the standard pallet loading system. In a similar freight/troop role, many combinations of *Vigilant* missiles and troops are possible, such as:—

(a) 184 *Vigilants* in lower freight holds, with 100 troops;
(b) 250 *Vigilants* in lower freight holds, with 87 troops;
(c) 250 *Vigilants* in lower freights holds plus 190 stowed in forward part of main compartment, with 50 troops.

A typical sortie carrying 184 missiles and 100 troops could be for a flying time of up to 15 hours.

Cost per Kill

In attempting to make a comparison of the costs of the various wire-guided infantry anti-tank weapons, undue emphasis is often placed on the bare cost of the missile, whereas this is only one of the factors contributing to the real cost, which is a complex of capital outlay and operating costs.

In equipping an army, cost is incurred in procuring both non-expendable equipment and stocks of missiles. The latter are expended partly in peace-time training, and at a considerably accelerated rate in combat. The level of missile stocks is determined by the numbers required to provide and maintain the required training strength together with the reserves of combat missiles. The cost of non-expendable equipment is small in relation to the cost of the missiles, so that the real criteria for comparing the costs of these types of weapon system are:—

(a) Training costs per man per annum
(b) Cost per tank destroyed.

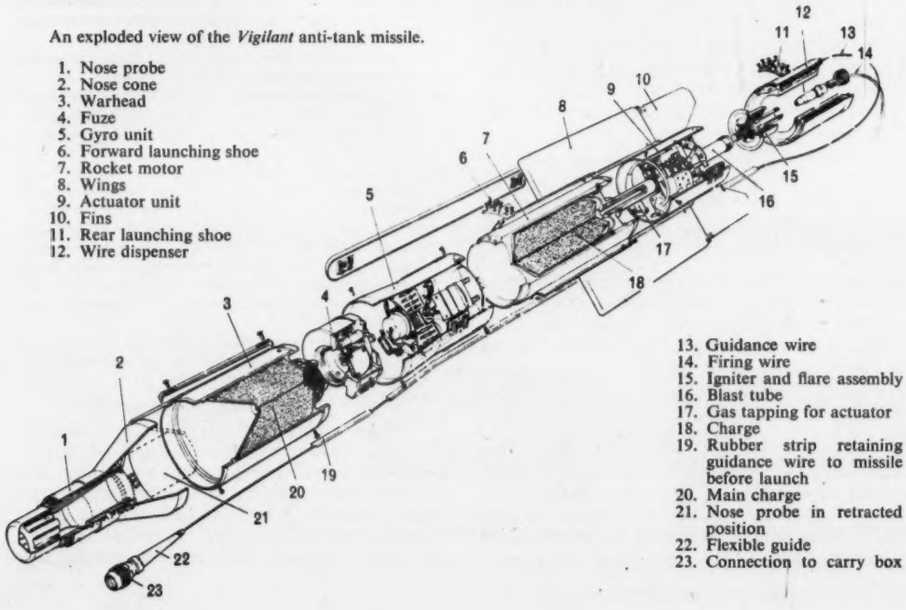
Vigilant is the lowest cost system, particularly as regards training. Furthermore, unlike acceleration guidance systems, *Vigilant* does not need specially selected high grade operators. It can be used by nearly all infantry soldiers.

The "cost per kill" comparison would be more marked if other factors had been included. In battery applications, for example, fewer *Vigilants* are required because of the wider coverage. More opportunities for tank kills occur with a given number of *Vigilants*, or alternatively the same opportunities with fewer missiles. This is due not only to its minimum range performance and wide angular coverage, but is also because its extreme portability and speed into action permit more rapid re-deployment. Its greater accuracy allows successful engagement when perhaps only the tank turret is visible at extreme range. Lethality is increased because the accuracy of *Vigilant* permits the more vulnerable parts of the target to be attacked.

Another most important factor is that of operational degradation under battlefield conditions. There will be some degradation of skill with any system, but it is an established fact that, the simpler the control system, the less the degradation. This results in a further increase of *Vigilant* cost advantage. When such factors are taken into account, comparison shows that, in terms of both training and tank destruction the Army can be equipped with *Vigilant* at less than half the cost of other systems. ⟶

An exploded view of the *Vigilant* anti-tank missile.

1. Nose probe
2. Nose cone
3. Warhead
4. Fuze
5. Gyro unit
6. Forward launching shoe
7. Rocket motor
8. Wings
9. Actuator unit
10. Fins
11. Rear launching shoe
12. Wire dispenser
13. Guidance wire
14. Firing wire
15. Igniter and flare assembly
16. Blast tube
17. Gas tapping for actuator
18. Charge
19. Rubber strip retaining guidance wire to missile before launch
20. Main charge
21. Nose probe in retracted position
22. Flexible guide
23. Connection to carry box



Business and Light Aircraft: The Way Ahead

By Peter Masefield, Managing Director, British Executive and General Aviation Limited.

In this sixth decade of manned flight, business aviation, and personal flying generally, is becoming a force to be reckoned with as a means of transport. And, although "general aviation" in the United States last year flew some four times more aircraft hours than all America's scheduled airlines put together, in business aviation we are still, everywhere, only at the beginning. The quickening tempo of both national and international trade throughout the World, the congestion on the roads, the flying habit promoted by the airlines, and the convenience of non-scheduled "at call" flying conspire to create a climate for the intensive expansion of business flying.

American light and business aircraft still dominate this particular sphere of aviation in 1961. Great names, such as Beech, Piper, Cessna, Aero Design, and Mooney, are adding to reputations which are respected and recognised throughout the world. Piaggio in Italy, Morane-Saulnier and Jodel in France, Dornier in Germany, and de Havilland in England all produce fine aircraft in this general class.

More and more, however, this sphere of aviation is becoming a specialised business, in which the right price of aircraft has to be allied to the right performance, and, again, the right performance to the right equipment and furnishings.

Above all, it has become an *international* business for, in the words of the great Cayley: "The air is an uninterrupted, navigable, ocean which washes at every man's door."

Thus the market exists, and it is one which will expand greatly in the next decade. Ten aircraft in operation in 1975 for every one today is not a piece of wishful thinking. This is a market at present largely met by American aircraft, which are excellent in their field. It is a market which will also respond to new approaches and to new equipment, provided they meet the major requirements at the right prices.

In an earlier and more spartan world, Britain led the way in light aircraft. The de Havilland *Moths*, Blackburn *Bluebirds*, Avro *Avians*, Simmonds *Spartans*, Miles *Hawks*, and Percival *Gulls* flew all over the world; and there are many of them flying yet. But only three names survived in the light aircraft field in England—Auster, de Havilland, and Miles,—and now two of them, Auster and Miles, are joined together in the British BEAGLE Group to specialise on a new range of British light and business aircraft. The third, de Havilland, has become part of the great Hawker Siddeley empire, devoted primarily to the more exotic forms of airline and military aviation, but with a new, sophisticated, business-jet to come.

British Executive and General Aviation Limited (BEAGLE) was, in fact, formed on October 7th, 1960, as a subsidiary of the Pressed Steel Company Limited of Cowley, Oxford. Its purpose is to concentrate on the design, development, and production of specialist, business, and lighter types of British aircraft. Its aim will be to produce a wider range in a field which British industry has greatly neglected in recent years because of pre-occupation with defence work and with aircraft for the airlines.

Shortly after BEAGLE's formation, negotiations were completed whereby both the Auster and the Miles companies became wholly-owned subsidiaries of BEAGLE as "BEAGLE-Auster Aircraft Limited" and "BEAGLE-Miles Aircraft Limited", located at Rearsby, Leicester, and Shoreham, Sussex, respectively.

At the same time, three inter-related families of light and business aircraft were put in hand in as many parallel BEAGLE design teams, all under the direction of the writer, as Managing Director, and of George Miles, as Technical Director.

The three design teams—and their initial products to be seen at the 1961 Farnborough Display —are:—

The Masefield-BEAGLE team (R.J.B. Woodhams—Chief Engineer).
First product, the BEAGLE B.206 twin-engine, five/seven-seat, low-wing business aeroplane (first flight August 1961).
The BEAGLE-Auster team (M. Langley—Chief Engineer).
First product, the BEAGLE A. 109 *Airedale* single-engine, four-seat, high-wing private and executive aeroplane (first flight April 16th, 1961).
The BEAGLE-Miles team (G.H. Miles—Chief Engineer).
First product the BEAGLE M.218, light twin-engine, four-seat, low-wing private and executive aeroplane, the furnished cabin of which is to be shown in the Static Exhibition at Farnborough.

These three aircraft are the first of the BEAGLE pack, which will be gradually extended to comprise a wide range of sizes—from two-seat to, eventually perhaps, about ten-seat. Other BEAGLES which will be on view at Farnborough are the BEAGLE-Auster A.O.P. Mark 11 STOL aeroplane for the British Army; the BEAGLE-

The first member of the BEAGLE pack to take the air—the A.109 *Airedale*, a single-engine, four-seater aircraft of medium price.

Current Beagle Projects

Model	Masefield BEAGLE B.206X	BEAGLE Auster A.109 *Airedale*	BEAGLE Miles M.218	BEAGLE Auster Mark 11	BEAGLE Miles M.117 *Martlet*	BEAGLE Auster A.61 *Terrier*
Type	Twin-Engine Executive	Executive/ Tourer	Light Twin	Army A.O.P.	Trainer/Tourer	Trainer/Tourer
Seats	5/7	4	4	3	2	2/3
Wing Position	Low	High	Low	High	Low	High
Engines	2×260 h.p. R.R. Continental IO-470-D	1×180 h.p. Lycoming O-360-A	2×100 h.p. R.R. Continental O-200-A	1×260 h.p. R.R. Continental IO-470-D	1×100 h.p. R.R. Continental O-200-A	1×145 h.p. DH Gipsy Major 10 Mark 2
Span	38′ 0″	36′ 0″	37′ 0″	38′ 5″	37′ 0″	36′ 0″
Length	32′ 7″	26′ 4″	25′ 3″	25′ 8″	25′ 6″	23′ 3″
Height	11′ 3″	10′ 0″	7′ 5″	8′ 11″	7′ 5″	8′ 11″
Wing area (sq.ft.)	200	190	170	198	170	184
Empty weight (lb)	3,750	1,630	1,610	1,650	1,095	1,635
AUW (lb)	6,000	2,750	2,750	2,550	1,550	2,350
Fuel capacity (I.G.)	150	52	70	30	38	22
Cruise speed (kts)	196	123	122	128	100	96
Basic List Price (sterling)	£ 27,000 (provisional)	£ 4,750	£ 5,000 (provisional)		£ 2,000 (provisional)	£ 1,995
First Flight	August, 1961	April 16th, 1961	Summer, 1962	August, 1961	Summer, 1962	April, 1961

Auster A.61 *Terrier* two/three-seat, light trainer/tourer and—in mock-up form—the projected BEAGLE-Miles M.117 *Martlet* two-seat, light, low-wing trainer/tourer.

All these types—as well as the BEAGLES still to come—will be powered by Rolls-Royce Continental engines, ranging in horsepower from 100 to over 300. Turbines, will no doubt, come along a little later. But, for many years to come, the piston engine with its qualities of cheapness, reliability, and relative smoothness in its "flat" form, with fuel injection and the advantage of low fuel consumption, will remain the major force in light "general aviation."

There are seven factors which are fundamental to a successful executive aeroplane. They are:—

1. **Reliability** — Good engines, combined with simple, but adequate, systems and maintenance characteristics.
2. **Performance** — Satisfactory standards to meet specialist requirements of takeoff, landing, and cruising flight.
3. **Handling** — Good flying characteristics, combined with a good view from the cabin to meet the requirements of both the professional and the amateur pilot.
4. **Comfort** — Advanced standards of furnishings combined with adequate room—both leg room and seat width.
5. **Economy** — Quality achieved at costs appropriate to the specialist market.
6. **Equipment** — Ability to instal radio, navigational, and other items of equipment which are required for modern operations.
7. **Looks** — "A good aeroplane looks right" (the converse is not necessarily true). To sell, modern aeroplanes must have aesthetic appeal.

We, in BEAGLE, believe that each of these seven fundamentals requires specific and specialist attention and this is what we are aiming at. For instance, Professor A.D. Young of Queen Mary College is a BEAGLE consultant on aerodynamics, and Professor Misha Black of the Design Research Unit is a BEAGLE consultant on styling and interior design.

Although we have put the first of our new products into the air in the space of less than a year, we are under no illusions about short cuts to the right answer in this intensively competitive international business. Success in aeronautics comes as a result of ceaseless endeavour, restless dissatisfaction, intensive development, and a determination to improve detail.

We are building up what will, we believe, be a fine and enthusiastic team in BEAGLE, almost all of whose members fly themselves and enjoy it. We are confident that, in the BEAGLE B.206, we will have an aeroplane which will hold its own in the skies of the world against the best that competition offers. And its "pack-mates" will, we trust, each fill their different roles to the satisfaction of both the designers and the users.

By Farnborough time, in 1962, we hope to show that prototypes can be rapidly followed, by production—and that production of the right types at the right prices, with the proper after-sales backing, will command world-wide support.

Liquid Oxygen Equipment for Aircraft Breathing Systems

By: Simon Kugler B.Sc (Eng), A.M.I.Mech.E., A.F.R.Ae.S., Chief Development Engineer, Aircraft Development Department, British Oxygen Co. Ltd.

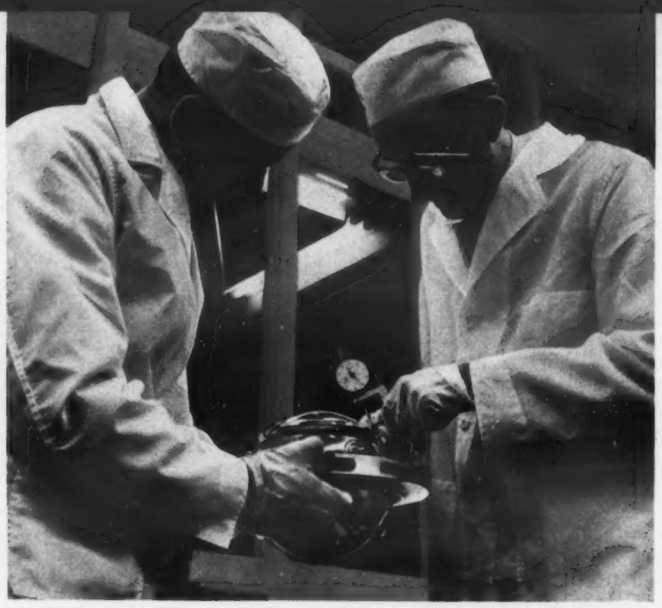
As—thanks to the invention of the jet engine—the operating altitudes and ceilings of modern military and civil aircraft are continually increasing, the oxygen system is taking an even more important part in ensuring the safety of the aeroplane and its occupants. For we require a continuous supply of oxygen to our lungs to sustain life, at a partial pressure which must not be reduced substantially below its sea level value.

Due to the reduction in ambient air pressure with altitude, the oxygen pressure in the lungs also drops, and reduces to insignificant proportions between 25,000 ft and 30,000 ft when air is breathed. By breathing 100 percent oxygen, the oxygen pressure in the lungs is increased considerably, but even so it reduces to nothing at about 52,000 ft, and above that altitude oxygen is actually given off from the blood, rather than absorbed by it.

Thus it is found that some supplementary oxygen is required to maintain efficiency from about 10,000 ft upwards—night vision deteriorates at much lower altitudes—increasing to 100 percent at between 30,000 and 35,000 ft, and from 40,000 ft upwards the oxygen must be supplied under an increasing pressure.

For this reason the cabin on modern aircraft is generally "pressurized," to provide an acceptable environment, and on civil aircraft the pressure is usually kept to an equivalent altitude of about 5,000 ft. However, cabin pressurization has been known to break down, and if the pressure cabin is punctured—for example on military aircraft by enemy action—explosive decompression may result. For this reason on military aircraft in combat zones, a lower differential pressure is used, and the equivalent cabin altitude is usually of the order of 25,000 ft. At such altitudes the use of oxygen equipment to maintain efficiency is essential, and even at low cabin altitudes emergency oxygen equipment must be provided in case of failure of the cabin pressure.

A typical liquid oxygen system, the 25 litre unit, weighs only 102 lb when full, while gas cylinders to supply the same amount of oxygen weigh 401 lb. The space and weight saved with the liquid system is illustrated here by the 25 litre package unit alongside the ten 1,800 p.s.i. cylinders required to store the same amount of oxygen in gaseous form.



The assembly of a 3½-litre vacuum insulated liquid oxygen container at the British Oxygen Aircraft Works. Apart from the precision engineering demanded, the construction must be carried out in surroundings of surgical cleanliness. The presence of oil or grease on components used in oxygen systems presents a serious explosion hazard in service.

The need for oxygen equipment on aircraft was first felt in 1917, as operating altitudes increased. A gaseous oxygen system was constructed from components then commercially available. However, the weight of these commercial cylinders proved prohibitive for long flights and thus liquid oxygen equipment was shortly introduced.

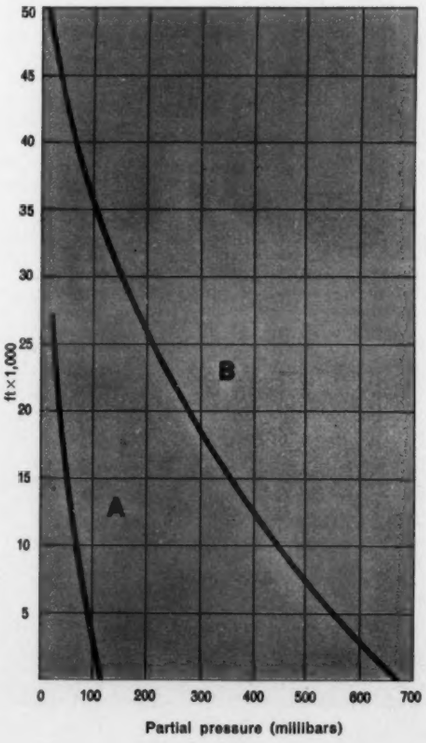
For some years after this the RAF used both gaseous and liquid oxygen systems. However, the supply position for liquid oxygen was not easy, particularly abroad, at out of the way depots, and so liquid oxygen went out of favour, and by 1930 gaseous oxygen systems, operating at 1800 p.s.i., were used exclusively in the RAF and Royal Navy.

The decision to re-introduce liquid oxygen into service aircraft was made in 1957. For some years prior to this B.O.C. had been working on acquiring the know-how of liquid oxygen converter construction, drawing both on their large experience in the design and manufacture of large liquid oxygen storage tanks and plant. Building upon this knowledge B.O.C., under a development contract awarded by the M O A., pioneered the re-introduction of modern liquid oxygen equipment into the latest British Service aircraft. In the first instance, a 3½-litre system was evolved for use on fighter-type aeroplanes, and this is now going into service on such diverse aircraft types as the Blackburn *Buccaneer*, Folland *Gnat Trainer*, de Havilland *Sea Vixen*, and the various Marks of English Electric *Lightning*. More recently there has been growing interest in LOX systems for transport and passenger aircraft and a 25-litre system has been developed by B.O.C. for use on the Armstrong Whitworth *Argosy C.1*, the Short *Belfast* and the de Havilland *Comet 4C*.

The case for LOX

This can be summed up in two words, "Weight" and "Space." At atmospheric pressure, the density of liquid oxygen at its boiling point is somewhat greater than that of water—its boiling point is -183°C (90°K), and its density, is 2.52 lb/litre. Due to the high density there is a considerable saving of both weight and space when storing oxygen in liquid form, compared with the conventional gaseous system at 1,800 p.s.i. The big advantage of liquid oxygen is brought home if it is realised that 1 litre of liquid oxygen when boiled and expanded will give approximately 840 litres of gaseous oxygen at N.T.P., thus even when the oxygen is stored at 1,800 p.s.i., the density ratio between gas and liquid is still of the order of 7 to 1. Storage at a higher pressure is possible, for example in fibre-glass vessels, but to achieve a density ratio of 1 to 1 a pressure of 12,000 p.s.i. is required. A liquid oxygen system occupies somewhat more space than appears from this simple comparison, because of the insulation required on the containers and additional control valves, but in general terms this does not invalidate the argument.

A comparison of the reduction in partial oxygen pressure in the lungs with the reduction of ambient air pressure. Curve A shows the partial pressure reduction in the lungs when breathing air, and Curve B when breathing 100 percent oxygen.



The weight advantage accompanying the reduction in volume is increased, as liquid need not be stored at high pressure—on the contrary it is advantageous to keep the working pressure as low as possible. This incidentally also increases the safety of the liquid oxygen system.

The LOX system and its components

Liquid oxygen, due to its low boiling point, is stored in very efficiently insulated containers. These vessels are normally double-walled; the inner container holds the liquid and the space between the walls—the "interspace"—provides insulation. Heat flow into the inner vessel is minimised by —

a) Careful design of the suspension system, to give maximum strength for minimum "cross-sectional" area and longest heat path;

b) Inlet and outlet connections crossing the interspace are carefully coiled up to give the maximum possible length of conductive heat path, and wall thickness is reduced as far as possible;

c) To eliminate gas conduction and convection, the interspace is pumped to a high degree of vacuum, of the order of 10^{-5} to 10^{-6} mm.Hg.

d) To reduce radiation loss, the surfaces are carefully polished and treated to reduce emissivity to a minimum.

By these means the inevitable loss of oxygen by boiling has been reduced, typical present day figures being 12–15 percent of total contents in 24 hours for the small 3½ litre container, and 5 percent in 24 hours for the larger 25 litre vessel.

The liquid oxygen container incorporates a capacitance probe, used for contents gauging. The probe forms a condenser, with the liquid oxygen forming the dielectric. The change of dielectric constant with LOX contents changes the

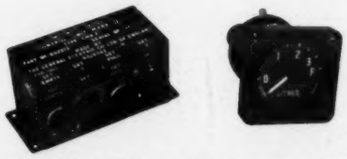
The oxygen system of a Folland *Gnat* trainer is replenished with liquid oxygen from a 50-gallon vacuum insulated dispenser. The dispenser unit has been specially designed to meet the requirements of the NATO forces.

capacitance value of the probe. This change is sensed in a transistorized gauging unit which converts it into a contents reading on an indicator.

The liquid oxygen system is fully automatic in operation. It is pressure filled from a ground dispenser via an airframe-mounted Fill and Vent Valve to which is connected a mating valve, known as a Ground Half Coupling, which conforms to NATO/USAF standard. On completion of filling, the system automatically pressurizes by vapourising a small quantity of LOX in a pressurising circuit and passing it back into the container. The Pressure Control Valve controls the process and ensures that the desired working pressure is maintained. It also incorporates relief valves and an economiser feature which allows gas from the top of the container to be utilised for breathing instead of going to waste. Normally liquid oxygen is supplied from the bottom of the container on demand to the regulators and aircraft distribution system.

The Ground Half Coupling, designed to NATO/USAF standard, which connects the dispenser to the aircraft system.

The airframe-mounted Fill and Vent Valve, which mates with the Ground Half Coupling.



The transistorized gauging unit and contents indicator. The gauging unit senses the change in the capacitance value of a probe in the liquid oxygen container.

The Pressure Control Valve is mounted in the aircraft oxygen circuit and ensures that the correct working pressure is maintained.

Future developments

Improved Heat Exchangers—Liquid oxygen is very cold, and must be evaporated and warmed up before it can safely be supplied for breathing. Present practice is to run the liquid through a length of pipe, usually coiled up, before passing it to the aircraft distribution system, relying on natural convection from atmosphere to provide sufficient heat. This is adequate for single seat or two-man aircraft, but with the large flow rates which will be required for emergency passenger use on modern transport aircraft several hundred feet of pipe may be required. Hence more efficient heat exchangers are being investigated, such as finned tubing and extended sheet vapourisers, relying on natural convection. If a source of air is available, forced convection may be considered, or even a matrix type heat exchanger, although this may introduce problems if the air supply is wet, due to freezing up of the passages.

Improved Container Insulation—The major portion of the heat inleak into present day LOX containers is found to be due to radiation. No great improvements can be expected in reducing further the emissivity of the interspace surfaces and means must, therefore, be found of introducing radiation "shields" into the interspace. Two parallel methods are at present under investigation—both are referred to as "Superinsulation."

a) A multi-layer sandwich of aluminium foil interleaved with fibre-glass paper or other non-conducting "spacers" may be wrapped around the inner vessel. This material is light and highly efficient. It is found that ½ inch to 1 inch of sandwich of this type almost completely eliminates radiation through the interspace.

b) The interspace may be filled with a "reflecting powder." This is a mixture of non-conducting powder particles (such as "Santocel") with aluminium or copper flakes. Again the purpose is to provide radiation shields interspersed with non-conducting spacers. This material, although offering improvements over present day converter performance, is more suited to ground equipment, where a thickness of several inches of powder is possible, without having to consider the weight and space penalty.

A high degree of vacuum is still required with these insulants.

The introduction of "Superinsulants" will also make it worthwhile to consider improvements in the method of suspension of the inner vessel of the container. Present designs are probably near the limit of their development potential and new methods will have to be investigated. This will be no easy task, for what is required is a suspension combining high strength with low thermal conductivity, and excellent resistance to vibration and accelerations experienced in modern aircraft. It must be borne in mind that any system evolved has to be compatible also with a high degree of vacuum required in the interspace.

Packaging

Originally, liquid oxygen systems were fitted nto aircraft already in existence and the individual components had to be installed where convenient and piped up in situ. An improved method now coming into use is to package all the equipment, preferably on a drip-tray to catch condensation, and install the complete package in the aircraft. This enables most of the piping up and system testing to be done on the bench and improves serviceability.

Supersonic Aircraft

Paradoxically, it appears that the need for oxygen systems on supersonic aircraft will be less than at present. Such aircraft will probably fly at altitudes of 70,000 ft or more and, therefore, a failure of cabin pressurisation cannot be contemplated without catastrophic results. Passenger oxygen equipment under these conditions will be well-nigh useless—except in the case of a "slow puncture"—but there may well be a case for providing protection for the crew, so that in case of cabin pressure failure, there is a chance of recovering the aircraft for an investigation which may prevent a recurrence.

Space Flight

All oxygen required for space flights must of course be taken along, but the systems used will no doubt be very different from the ones employed at present. Even if LOX is carried for the engines all oxygen will have to be preserved jealously if flights of more than a day or two are contemplated. For such flights, closed cycle systems are likely, and regeneration of oxygen from the exhaled CO_2 either chemically or biologically (e.g. algae), a definite probability. ⟷

The Alvis Stalwart

By D.H. Wood, Interavia, *London*

At the close of World War II the armoured car had fallen from favour and the accent lay on tracked and half-track vehicles for support, supply and battle roles. Only in Britain and France was there continuing development and production of armoured cars.

More recently, the situation has changed radically, with wheeled vehicles scheduled to take over an increasing number of load- carrying and battle tasks. Germany has renewed her interest and the United States is coming back into the field.

Chassis and suspension evolution have now reached the point where the wheeled vehicle can travel almost anywhere its tracked counterpart can go. The main factors governing the swing from tracks to wheels are as follows:—

1 – Ease of maintenance.
2 – Lower cost of operation.
3 – High speed and quietness of movement.
4 – Minimum crew fatigue.
5 – Absence of damage to roads and lines of communication.
6 – High payload.

The modern generation of wheeled load carriers is represented by the *Stalwart* produced by Alvis Ltd. of Coventry, England. Initially developed as a private venture 5-ton load carrier (water, ammunition, petrol etc.) to replenish tank formations, the *Stalwart* is now being considered for roles as diverse as a light helicopter/VTOL aircraft platform or as a mobile guided weapon launcher.

The British War Office originally intended that its new amphibious army load carrier should be tracked, but subsequent studies and exercises proved that a wheeled vehicle with high performance on roads and across country would be more suitable. To Alvis, the answer was clearly a load-carrying development of their successful range comprising the *Saladin* armoured car, *Saracen* troop-carrier, and *Salamander* crash tender—all of which employ a six-wheel layout with eight years user experience behind it.

Alvis built a prototype *Stalwart,* with a civilian cab and a simple drop-sided cargo area superstructure, which was turned over to the War Office. Extensive trials were carried out under extreme terrain conditions and the final report was most favourable.

From this prototype the Company has now evolved a basic production model for army use, which can be modified to suit a wide variety of other requirements.

The *Stalwart* is a frameless vehicle with a boat-shaped waterproof hull mounted on six independently sprung wheels—all six being both driving and braking—with differential action between offside and nearside.

The powerplant, a Rolls Royce B.81/80B of 220 b.h.p. is at the rear and the sealed

The *Stalwart* undergoing water trials. The only preparation required before taking to the water, is the installation of the splash panel in front of the cab.

A head-on view of the *Stalwart*. The disposition of the cab and load carrying platform above the boat-shaped hull can be seen from the photograph.

cooling system employed includes a gilled tube radiator, belt-driven 17-inch aerofoil fans and circulation by centrifugal pump controlled by a bellows-type thermostat.

For water propulsion and steering, two Saro/Gill propulsion units are fitted, one on each side of the hull; they are driven by a mechanical drive through a power take-off. The *Stalwart* can also be water steered on wheels alone.

The independent suspension system is of the parallel link type providing 5 inches bump and 5 inches rebound, giving a total of 10 inches vertical wheel travel. A torsion bar spring is fitted at each wheel station, with damping and absorption effected by hydraulic shock absorbers on all wheels. Suspension

The vehicle demonstrates its cross country ability. The suspension enables vertical obstacles up to 1'9" in height to be negotiated.

The *Stalwart* running ashore on a beaching exercise. The vehicle is capable of swimming ashore after launching from the ramp of a landing craft.

Characteristics of Stalwart P.V.2. (Subject to alteration as the result of trials.)

Crew	3 or 2 + W/T equipment	
Cargo area	12' 2" × 7' 10½"	
Payload	5 tons	
Weight laden	13.3 tons	
Power/weight ratio	16.5 b.h.p./Ton	Gross b.h.p.
Fuel capacity	100 I.G.	
Length	20' 6"	
Height	8' 1"	Commander's hatch removable for air stowage, reducing height to 7' 9"
Ground clearance	1' 6"	
Vision, commander and driver	Direct	Cab can be modified to meet various specifications.
Communications	Fully suppressed	Any War Dept. set can be fitted.
Engine	Rolls-Royce B80/81B	K60 can be fitted as replacements to B Series.
Transmission	Twin 12" clutch—synchromesh gearbox	Alvis anticipate that the following types of transmission will be available for *Stalwart:* a) Fluid Coupling and Wilson gearbox. b) Twin plate clutch and 5-speed synchromesh. c) Allison automatic transmission (possibly).
Brakes	Caliper disc	Installation of Girling totally-enclosed disc brakes is anticipated.
Gearbox ratios. Reverse in the transfer box giving 5 forward and 5 reverse speeds	Gear ratio / Overall ratio 5 1.0 / 11.666 4 1.565 / 18.141 3 2.744 / 32.012 2 4.770 / 55.647 1 7.685 / 89.65	Tests will also be carried out on the following: Gear ratio / Overall ratio 5 1.00 / 12.902 4 1.54 / 19.869 3 2.57 / 33.158 2 4.17 / 53.801 1 8.00 / 103.22
Suspension	Torsion bars	
Air-portable weight	19,000 lb	
Flotation: — — Shallow fording — Laden	Sealed hull (5' approx.) By 2 Saro/Gill propulsion units, steerable.	With no preparation Tank test at Saunders Roe Marine gave estimated speed in excess of 5 knots.
— Swimming from landing craft	Yes	
Max. road speed	54 m.p.h. (4,000 r.p.m.)	
Range of action	450 miles	

components and final drive assembly are interchangeable between wheel stations.

The transmission has a multi-dryplate clutch and 5-speed synchromesh gearbox. A transfer box incorporates forward and reverse change and differential drive direct to each centre wheel hub through universally jointed shafts. Drive to front and rear wheel hubs is by transmission shafts and bevel boxes. Each wheel hub houses an epicyclic train which provides the final gear reduction to the wheels. An Allison fully automatic gearbox is being installed for trials to be carried out later this year.

Normal steering is hydraulically assisted to reduce crew fatigue and the hydraulic caliper disc brakes on all six wheels are operated from the footbrake which has air pressure boost on the driver's pedal. Two transmission brakes work from the handbrake, which is of the mechanical rachet type.

On its trials, the *Stalwart* achieved a maximum road speed of 54 m.p.h., surmounted a vertical obstacle of 1 ft 6 in, a gradient of 25°, and a trench crossing of 5 ft 9 in. Initial water trials showed a water speed in excess of 5 knots.

The *Stalwart* is air-portable and can be carried in such aircraft as the Armstrong Whitworth *Argosy*, Blackburn *Beverley*, Lockheed *Hercules*, and *Transall C-130*.

As part of future trials, Alvis plan to undertake an unusual exercise. A *Stalwart* will be loaded in England and driven with a crew of two to a point in Germany, crossing all land and water obstacles en route, including the English Channel.

First water trials have recently been completed, and the *Stalwart* has been ordered in pre-production quantity by the British Army. Interest is already being shown by air force and foreign army authorities, as well as by civilian organizations. →→

The *Saladin* armoured car which employs the same six-wheel layout of chassis as the *Stalwart*.

The *Saracen* troop carrier is more lightly armed than the *Saladin*. Possessing a good cross-country performance, it is extremely suitable for reconnaissance units.

GNOME

GYRON JUNIOR

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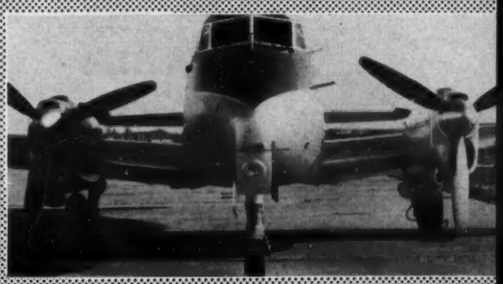

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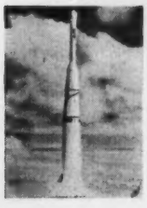
DISCOVERER SERIES Position gyros to aid vital satellite recovery programs have been developed and produced for this series by General Precision.



EXPLORER SERIES Over 20 General Precision components have assisted in the launching of these satellites.

MIDAS General Precision has developed and is now producing control moment gyros to stabilize MIDAS satellite with reference to earth when satellite is in orbit.

Thes major sytems interpreted here are testimonials to General Precision's experience in space. The four divisions of General Precision, Inc., are represented by some system, subsystem or component on nearly every satellite,space vehicle, missile and rocket now in operation or development.

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GENERAL PRECISION AND SPACE

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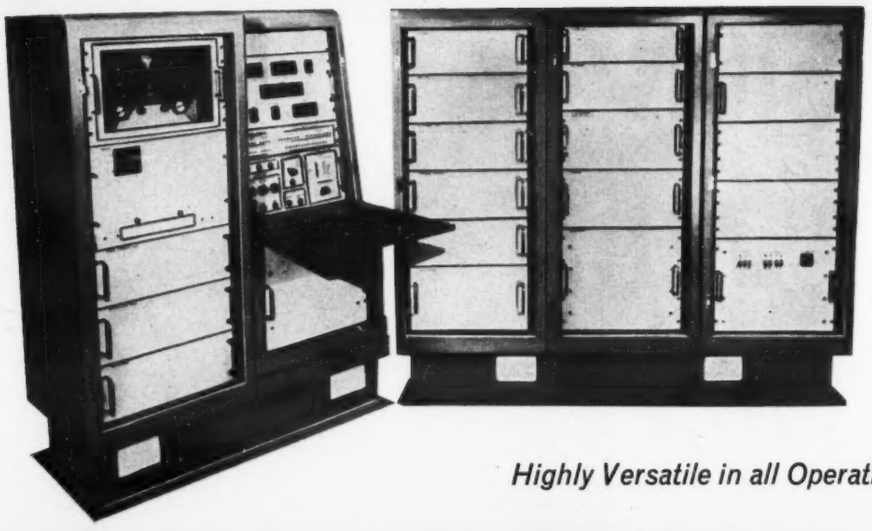

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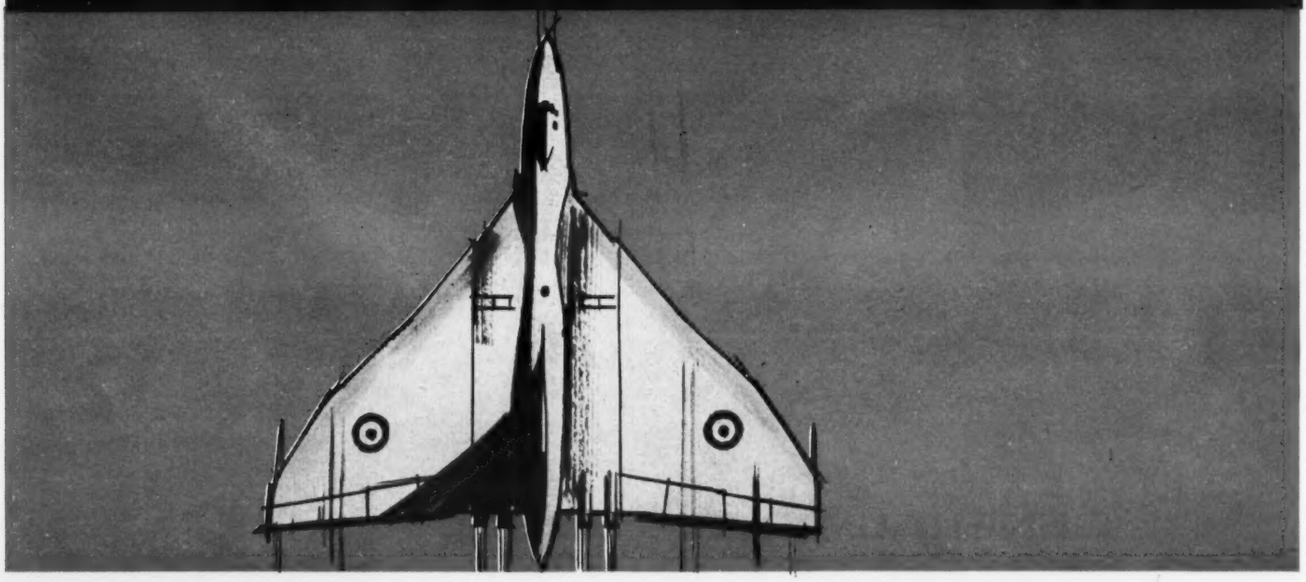

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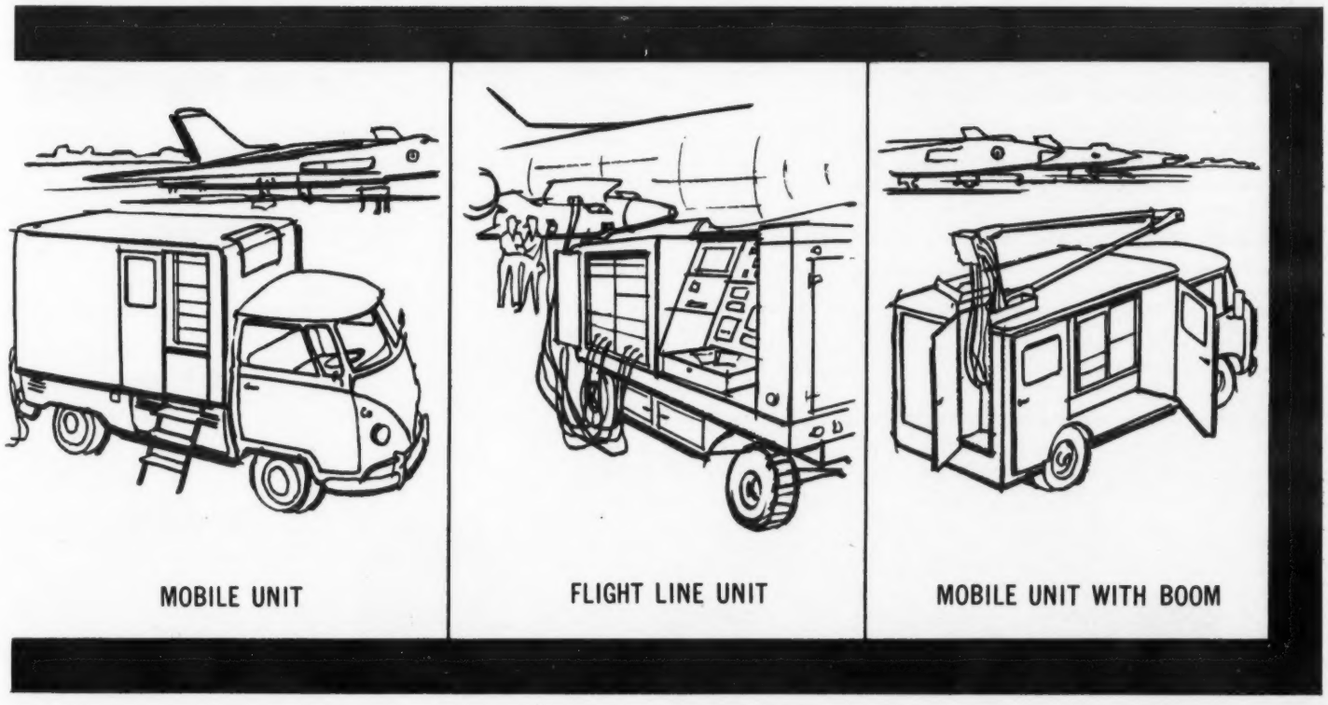

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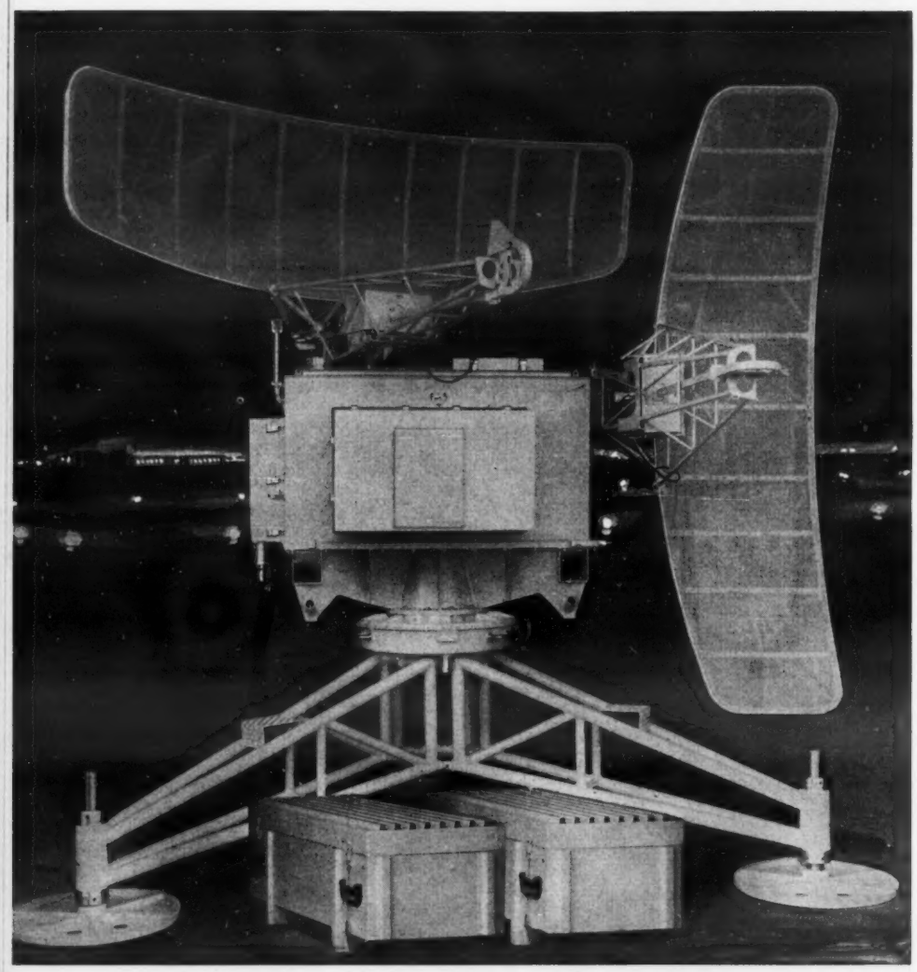

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The equipment works in the 225-399.9 Mc/s frequency range on 3,500 channels spaced at intervals of 50 Kc/s. Any one of these frequencies can be selected without difficulty. COMPAGNIE FRANÇAISE THOMSON-HOUSTON manufactures a similar 1,750-channel equipment operating in the same range.

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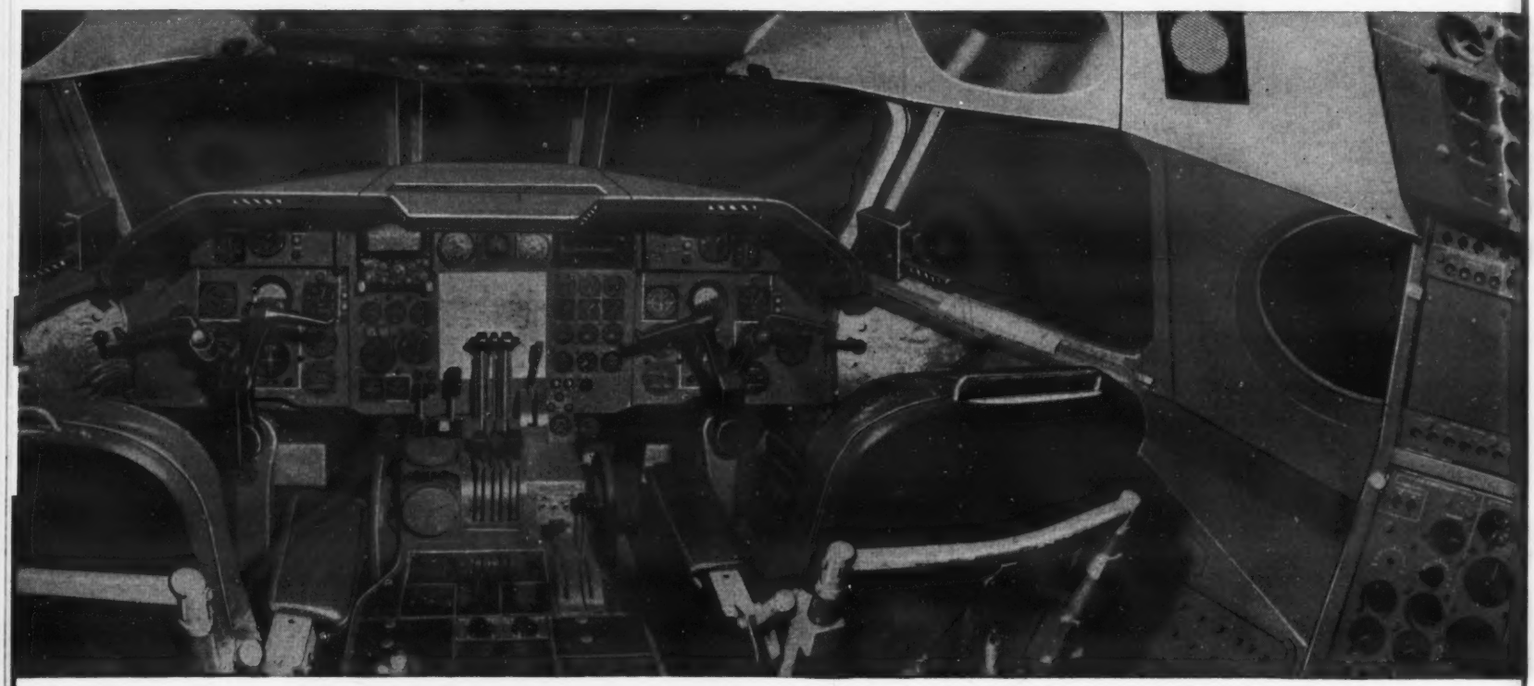
Smiths are in the picture



This is a mock-up of the BEA de Havilland Trident cockpit. Smiths equipment has been specified to provide automatic flare control when the aircraft enters service. Smiths S.E.P. 5 automatic pilot (the pilot's controller is in the bottom centre of the picture) operates on the Multiplex principle and will, ultimately, provide full automatic landing facilities to civil safety standards. Smiths Para Visual Director (P.V.D.), a revolutionary flight director display, can be seen around the panel coamings. In the Trident Smiths P.V.D. will operate in conjunction with the new Smiths integrated Flight System, specifically designed in conjunction with BEA to fit the Trident's operational role.

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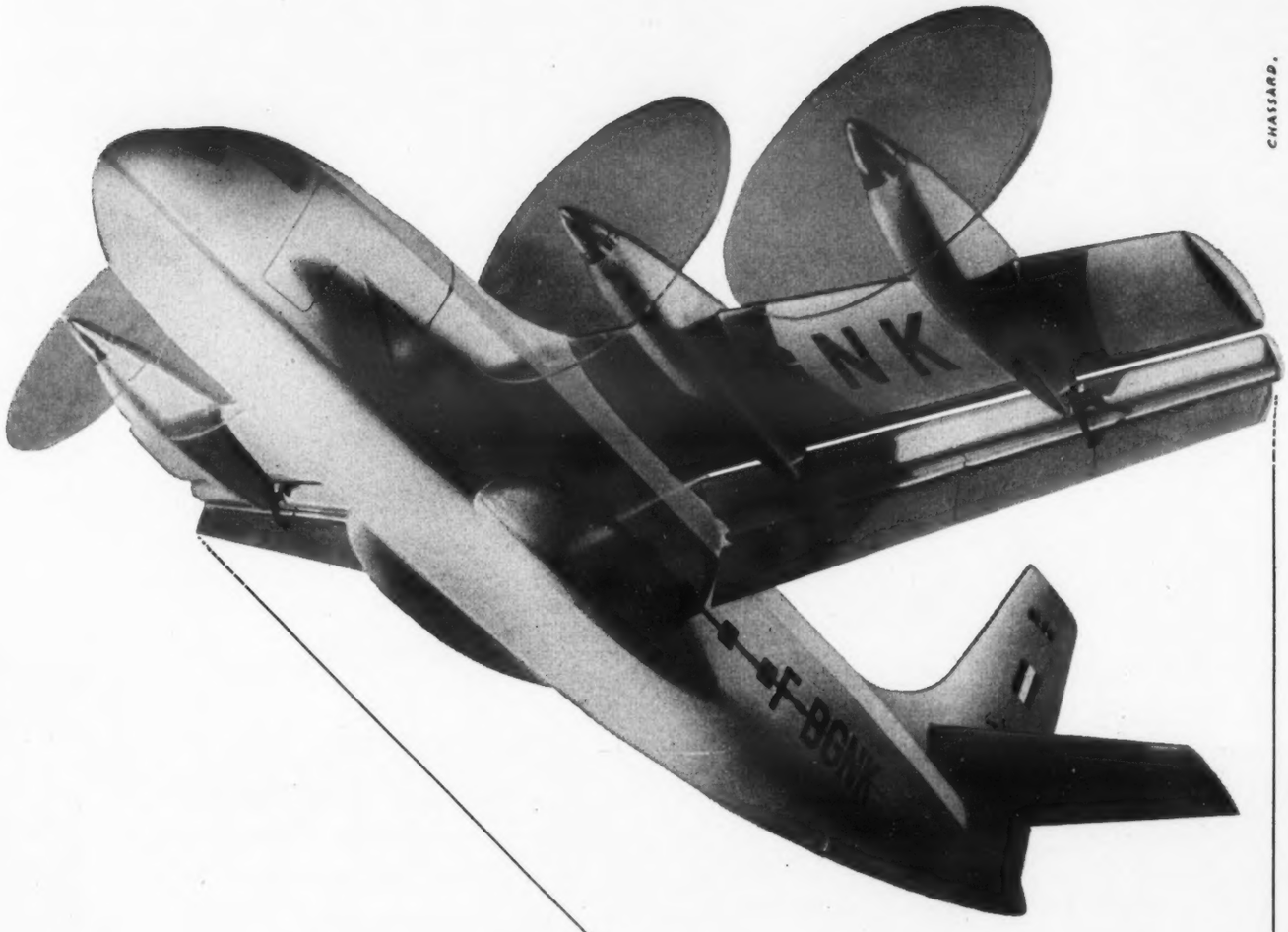

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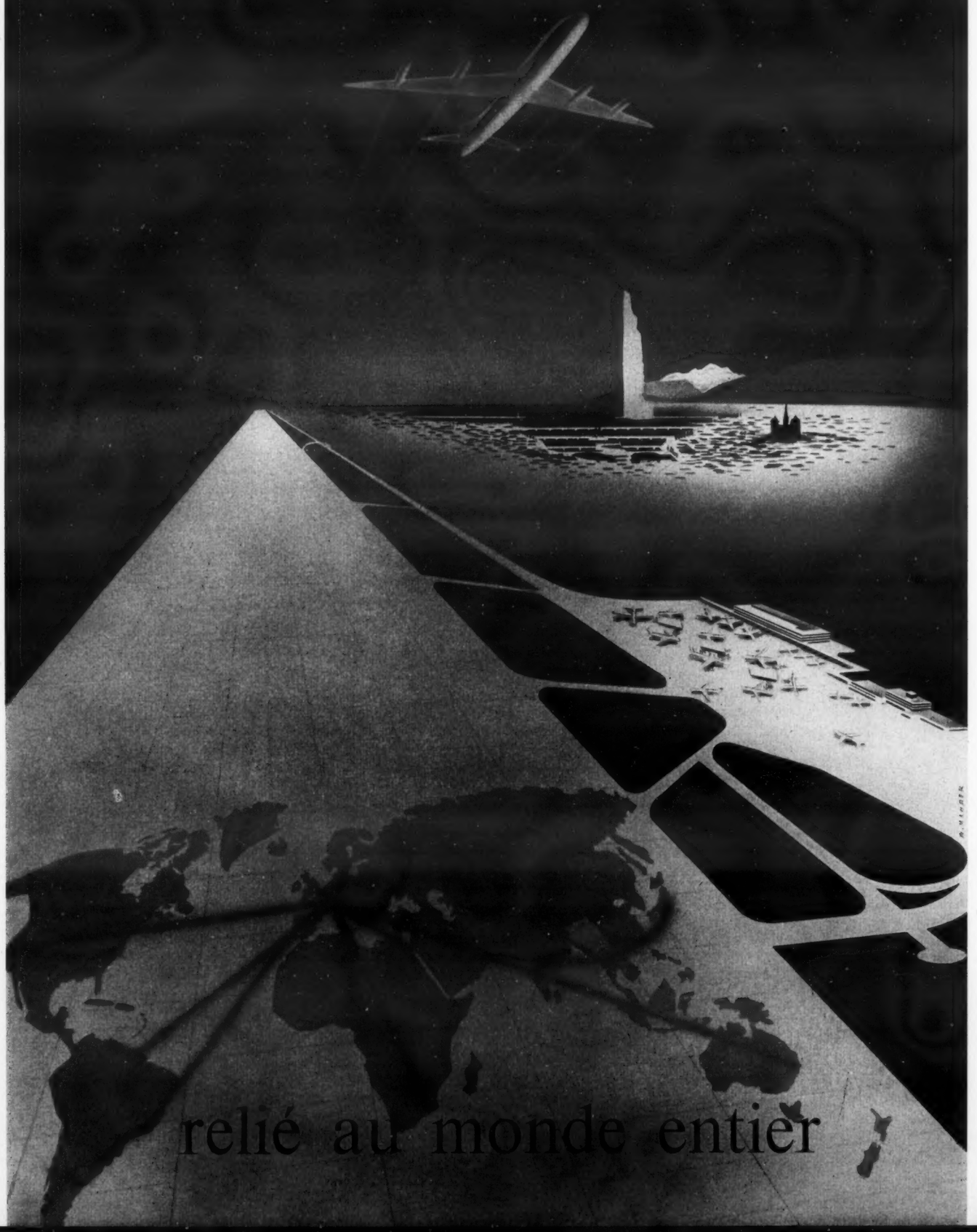

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CSF long-range radars, which have already been chosen to equip Area Control Centres in France (Orly, Aix-en-Provence, Bordeaux and Lyons), Indonesia (Surabaya) and the Union of South Africa (Capetown), have now been selected by the Australian Government for Sydney and Adelaide.

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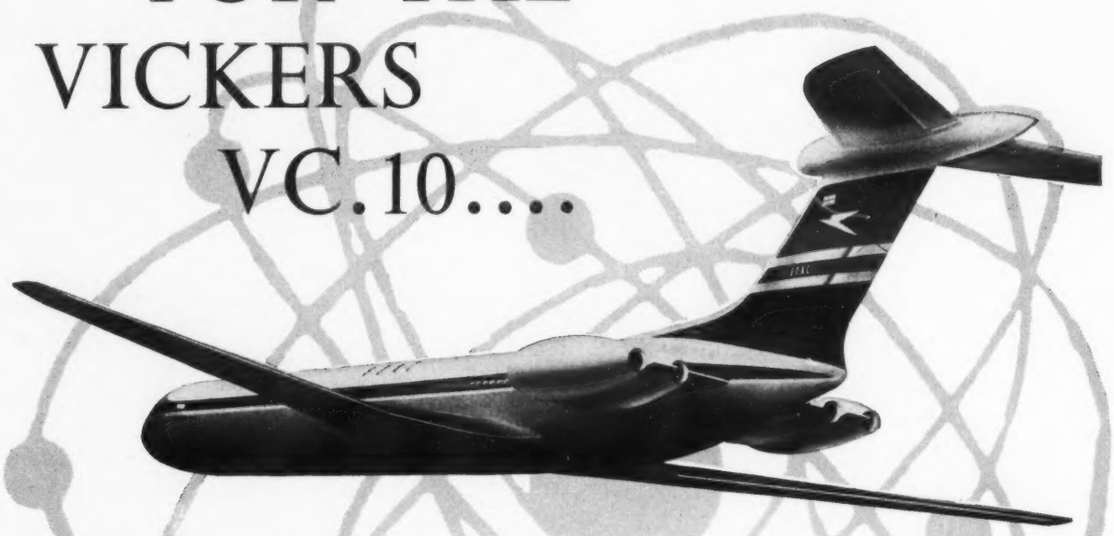
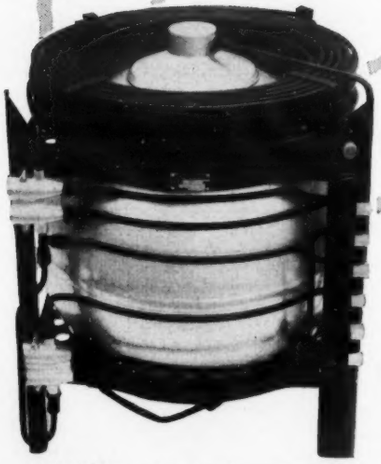
FOR THE VICKERS VC.10....





NORMALAIR 35-litre liquid oxygen converter

Weight (fully charged)	137½ lb.
Max. diameter	18 in.
Height	19 in.

NORMALAIR LIQUID OXYGEN EQUIPMENT

The NORMALAIR 35-litre liquid oxygen converter, featuring the exclusive NORMALAIR crew reserve system, is the choice for the Vickers VC.10, the world's first civil airliner to have a liquid oxygen system. One of a range of NORMALAIR converters, with liquid capacities from 10 litres upwards, it is the only wholly British designed and manufactured unit of its size available.

The crew reserve system automatically ensures an adequate crew supply at all times, irrespective of passenger demand, and enables both passenger and crew supplies to be drawn from one converter, with consequent savings on weight, space, maintenance costs and spares provisioning.

Other features of the converter are an extremely stable delivery pressure during flight, and greatly reduced evaporation losses due to heat transfer.

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What's in the Air?

The Fiat G.91 built in West Germany.

DEFENCE

Bloodhound, the guided missile for ground-to-air constructed by Bristol and Ferranti, has been ordered in large numbers by the Swedish Air Force. Our illustration (bottom right) shows the Mark 1 version on its launching device, as well as the control equipment, set up "somewhere" in Sweden. The most recent order is for the improved Mark 2 version, this being, according to Bristol Aircraft Ltd., the largest export order to date for this weapons system. Following Sweden's example, the Swiss Federal Council also recommended to the Federal Assembly in mid-July the provision of the British *Bloodhound Mk. 2* ground/air guided missiles involving expenditure estimated at 300 million Swiss francs. Moreover, to strengthen Swiss anti-aircraft defences, additional medium-calibre anti-aircraft batteries with electronic fire-control are to be procured, the cost of which may amount to 150 million francs. As regards the gun itself, the choice lies between the 35-mm *Oerlikon* twin-barrelled gun and the 30-mm *Hispano-Suiza* four-barrelled gun—the decision has still to be taken. The fire-control equipment will be the Contraves AG (Zürich) *Super-Fledermaus*.

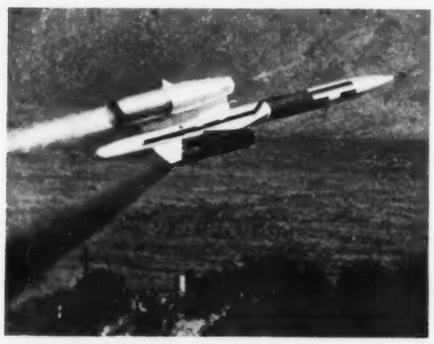
The first development phase of the **German Air Force** should be largely completed at the turn of the year. The Air Force will by then have 5 fighter-bomber wings, 3 reconnaissance wings, 4 fighter wings, 2 transport wings, 4 missile battalions and 8 anti-aircraft battalions plus, of course, various supply and depot units. At this point, there will also be one fighter bomber squadron in process of re-equipment. To this must be added one further reconnaissance squadron and one further transport squadron, which are being established. Of the existing units, four fighter-bomber wings, one reconnaissance wing, one fighter wing and one transport wing are already under the command of NATO. Further units will be seconded to NATO as soon as they are sufficiently operational. The *second phase build-up* of the Air Force will last until 1965/66; during this period, particular emphasis will be placed on the strengthening of fighter-bomber and transport units. In addition, missile units with both ground-to-ground and ground-to-air weapons will be formed. Parallel to these projects, the F-84s will then be replaced by F-104Gs. The total cost of the procurement of aircraft and missiles for the Bundeswehr during the second phase will be DM 9 to 10 thousand million. A special event was the first flight of the Fiat G.91 ground support aircraft built in Western Germany under Italian licence (see photo top right), which took place on the evening of July 20th at the Dornier-Werke trial airfield, Oberpfaffenhofen, near Munich. The flight lasted 36 minutes and, according to the test pilot's report, went off smoothly. The aircraft, designated ED-101, was handed over to the Luftwaffe for testing at the end of August.

The **Austrian Air Force** now has fifteen Saab 29F fighter bombers purchased from Sweden. At the beginning of July, these aircraft arrived at Vienna-Schwechat Airport (picture on this page centre right) and now constitute the *No. 1. Fighter-Bomber Squadron*, under the command of Major Rupert Thurner. The squadron, for the present based partly at Vienna-Schwechat and partly at Klagenfurt-Wörthersee airports, is to

Saab 29F fighters for Austria.

Bloodhounds in Sweden.

Flight testing of the Douglas A4D-5 marine combat aircraft has just started at Edwards AFB, California. The A4D-5 is, in fact, an improved version of the carrier-borne *Skyhawk* (pictured left). Flight testing was also started on the new version (2NE) of the Chance Vought F8U *Crusader* all-weather carrier borne fighter. The F8U-2NE (pictured right) is carrying four *Sidewinder* air-to-air guided missiles.



The Redhead-Roadrunner supersonic target drone, built by North American Aviation on behalf of the US Army. The drone takes off from a ramp. Located aft, on the underside of the drone, is a solid propellant booster (5,000 lb thrust) for acceleration during takeoff. In-flight powerplant is a Marquardt ramjet engine.

The design competition for a training and sports model, held by the WGL, the German Scientific Society for Aviation, resulted in a win for the SIAT 223 two-seat design, by Siebelwerke ATG (see picture below). This design can be regarded as a development of the SIAT 222 sports and touring aircraft (above).

move to its planned base at the Linz-Hörsching airfield in the late autumn. The Austrian Air Force will use its Saab 29Fs as truly multi-purpose aircraft.

INDUSTRY

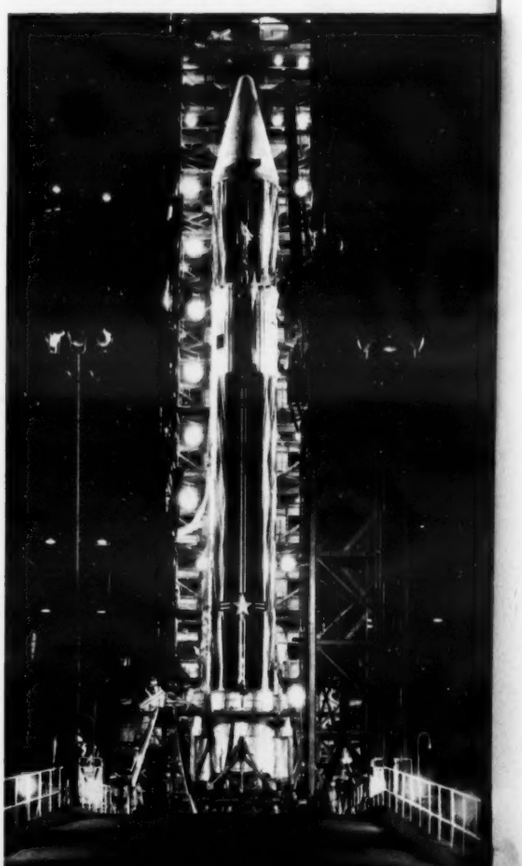
General Dynamics has delivered the first liquid oxygen/liquid hydrogen propelled carrier vehicle to the Cape Canaveral Missile Test Base. It is the 105-ft high *Atlas-Centaur* carrier rocket, which has been installed on lau ch platform No. 36 (below, right). General Dynamics/Astronautics built both the first stage, a modified *Atlas* intercontinental rocket, and the second stage, a *Centaur*. Flight tests of the *Atlas-Centaur* will begin this year, and it will be used for interplanetary space research in 1962.

Under a contract with the US Army Transportation Research Command (TRECOM), **Lockheed Aircraft** is developing a two-seater jet-powered VTOL research aircraft; this will be equipped with two Pratt & Whitney JT-12 turbojets, each developing about 3,000 lb thrust. This research aircraft, designated the *Hummingbird*, will have a 25.6-ft wingspan and an overall length of 32 ft. For vertical takeoff or landing, and hovering flight, the hot gas jets from both engines are led to an unspecified number of plenum chambers mounted aft on the fuselage, whence the blast is directed downward by deflectors to create lift. The upper and lower sides of the above-mentioned plenum chambers are provided with vents, corresponding with louvres in the skin, which can be closed during horizontal flight. In this case, the exhaust gases of both engines are expelled rearwards through conventional thrust nozzles.

The $90 million appropriation for the **Lockheed C-141 jet transport** (SOR. 182) already approved by the US House of Representatives, is temporarily pigeon-holed in the Senate, until the Kennedy Administration finalizes its reforms of American military policies. It is, however, anticipated that the various finance committees will report favorably on this proposed $90 million appropriation. In view of possible changes in research and development costs, however, the figure mentioned may be revised. According to information received from our Washington Correspondent, this revision is likely to be upward, owing to *higher appropriations for research development*. Meanwhile, discussions with the US Federal Aviation Agency (FAA) are continuing, in order to explore the possibility of using the Lockheed C-141 for commercial purposes in addition to troop transportation. It is understood that the Lockheed Aircraft Corporation design very nearly meets US Air Force specifications already. The final design will undoubtedly depend not only on technical considerations, but also on military considerations related to changes in the political situation. Lockheed Aircraft Corporation representatives decline to discuss the current situation regarding sub-contracts. These will not be worked out before late summer or early autumn.

The **first French-built satellite** is to be launched in 1964; a three-stage launch vehicle will be used, which will also be of wholly French construction. The first stage carrier rocket will have a liquid-

First Atlas-Centaur at Cape Canaveral.



fuel motor, while the second and third stages will be solid-fuelled. Agency reports from the French capital suggest that, in all probability, the launchings will be carried out at the *Hammaguir* launch site in the Sahara. The launching of the first French satellite, whose weight will be about 110 lb, will initiate a series of tests, which will involve quite a number of further small satellites to be placed in orbit around the earth. It is specified that these tests planned by France are to serve purely scientific purposes. In this connection, the family of high-altitude research rockets jointly developed by *Sud-Aviation and the CNET* have been mentioned, and their multi-stage vehicles are likely to be given consideration as satellite carriers.

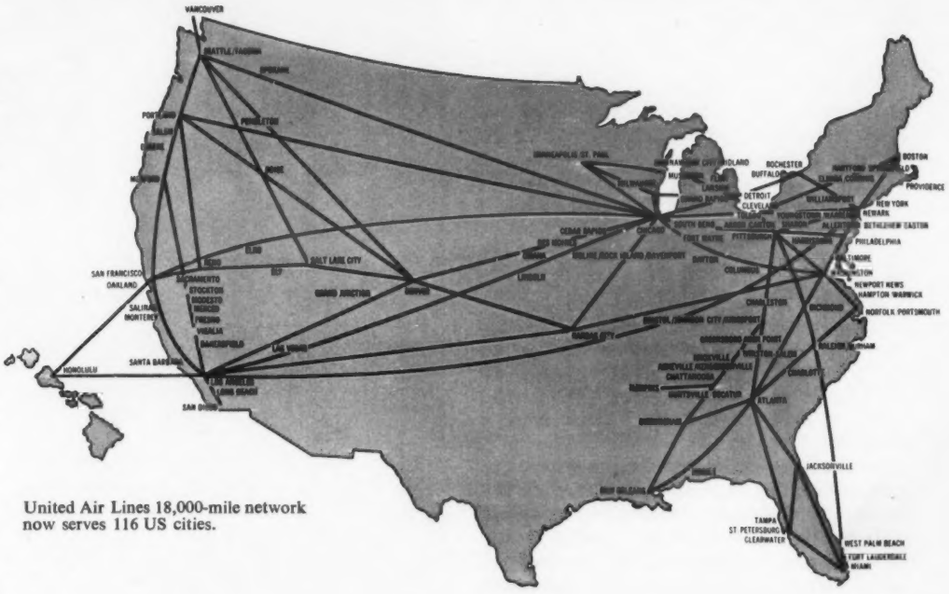
With its **Flash Cutting** system, the Société Aérazur of Issy-les-Moulineaux offers a new quick-opening device for emergency exits on aircraft. The system proposed by Aérazur requires no special structural stiffening of any kind, and uses neither bolts nor latches. *Flash Cutting* has one main component: a metal wire with a handle to be pulled in an emergency and capable of cutting through relatively thick skin plates with a pull of only 22 lb. The *Flash Cutting* device can be installed without weakening the fuselage structure in its vicinity, and it is suitable for emergency exits, astrodomes, etc. It will also cut through light-metal plates 0.08 in thick at the rate of over three feet per second. The length of a single cutting wire should not however exceed about three feet, so that larger apertures involve several individual wires.

Dassault intends to start soon on the construction of a small series of **two-seat Mirage IIIB's** for pilot training. Like the single-seat version, the *Mirage IIIB* will be equipped with the *ATAR 9C*. A mock-up of this two-seater has been built at the Dassault Works, Bordeaux, to allow study of the most advantageous layout for the various items of built-in equipment.

The Hispano-Suiza model SEPR 841 rocket motor, of which about 150 units have already been manufactured under a contract with the Armée de l'Air, will now be replaced by the **SEPR 844** model. The 844 (intended as an auxiliary engine for the *Mirage III*) has a thrust of about 3,300 lb. It uses nitric acid as the oxidizer, and JP1 or JP4 as fuel. The overall length of the 844 motor is 10.73 ft, and its maximum height is 25 in. One of the characteristics of the 844 motor is that its fuel pumps are powered by the aircraft's main jet turbine; the main shaft revolves at 5,080 r.p.m. The fuel pumps are started through a pneumatic clutch. Technical data available on the SEPR 844 are: maximum thrust at ground level 3,370 lb; max. thrust at 53,000 ft 3,700 lb; specific fuel consumption at full thrust and ground level is 10.8 lb/long ton/sec, and at 52,800 ft 9.8 lb/long ton/sec. Dry weight of the motor is 198 lb; weight of the complete unit ready to fly (motor, tanks, and compressed air systems for oxidizer feed, auxiliary equipment, etc.) is 500 lb.

AIR TRAFFIC

During the period under review, the accent was undoubtedly on **air traffic negotiations**. In mid-July, after months of negotiation, the Dutch delegation returned once again from Washington without landing rights for *KLM Royal Dutch Airlines*. The negotiations broke off without any date being fixed for resumption. *Alitalia* appears to be more fortunate; as reported from Rome at the end of July, the Italian flag-carrier can count on flying the Rome–Milan–Montreal–Los Angeles route beginning with the winter 1961/62 timetable. At time of going to press, nothing is known about the state of the *American-Soviet* air traffic negotiations, which started on July 18th. Closely connected with these negotiations, however, was an agreement between the Swedish Foreign Office and the competent Soviet authorities to commence formal *Swedish-Russian* air traffic negotiations in Stockholm on August 21st. Then there was the successful outcome to discussions concerning the extension of political relations in the field of air traffic, which took place at the end of July between representatives of the Federal Air Office, Swissair, and the Japanese authorities. As a result, *Swissair* can now extend its third Far-East route, which formerly terminated at Hong Kong, as far as Tokio. Other negotiations of interest were those between *Canada and America* on the local frontier traffic question. Since nearly all Canadian cities are situated near the American frontier, the US airlines are favoured in being able to rely on a much larger source of traffic to these cities. On the other hand, the Canadian services usually terminate in the American cities near the frontier, and passengers use American airlines for the continuation of their journey. There was, moreover, great indignation in Canadian airline circles over the recommendation by the CAB that *National Airlines* and *United Air Lines* (which became one of the largest American domestic operators by virtue of amalgamation with *Capital Airlines*—cf. air-route diagram top right) should link leading cities in the Washington-Philadelphia area with Toronto, via Buffalo (frontier). Since the negotiating parties were unable to reach agreement, the discussions have been deferred until this autumn. ←



United Air Lines 18,000-mile network now serves 116 US cities.

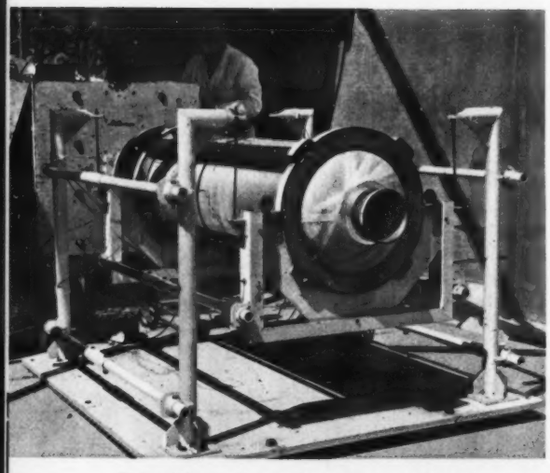
The French Potez 840 feeder aircraft. Series production at the rate of 100 per year is planned to start in 1963.

Rockets, Missiles, and Space Vehicles

The *Transit 4A* navigation satellite. The small white spherical object is a nuclear generator developed by the Martin Company. This auxiliary power source converts heat from the spontaneous decay of plutonium 238 direct into electrical current.

Shots into Space

The last few weeks have witnessed brisk activity at the American Atlantic and Pacific rocket launching sites. There were first the two successful launchings, following upon one failure, in the *Discoverer* series: on June 8th, 1961, *Discoverer 24* atop a *Thor-Agena B* launched from Vandenberg AFB, failed to orbit the earth as planned, apparently due to a malfunction in the second stage carrier-rocket. However, on June 16th, *Discoverer 25* went into orbit, with a perigee of 140 miles and an apogee of 250 miles. This 2,100-lb satellite has a 91-minute orbital period. Its 300-lb instrument capsule was ejected as planned, and was recovered in the Pacific near Hawaii. On July 7th, *Discoverer 26* was successfully launched (perigee 147 miles, apogee 506 miles, orbital period 95 minutes) and, after 32 orbits, its capsule was ejected; during the last stage of descent by parachute, it was retrieved in mid-air by a Fairchild C-119. Among other items carried aloft was an assortment of test samples of lead, iron, magnesium, nickel, silicon, uranium, bismuth, and yttrium. On the other hand, the attempt on July 21st to place *Discoverer 27* in orbit proved a failure owing to a booster rocket malfunction shortly after launch, which necessitated its remote-controlled destruction.

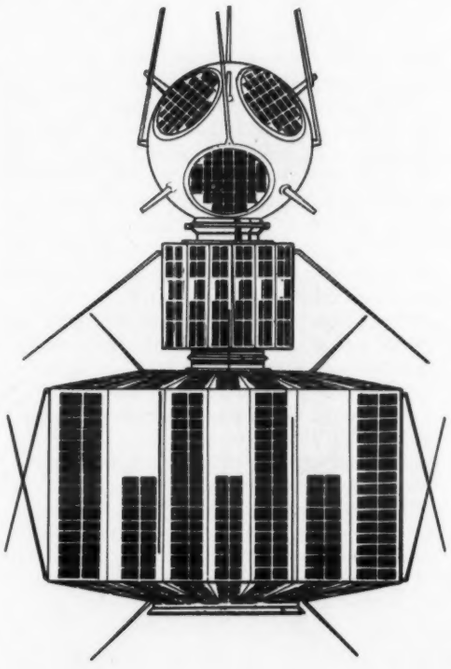


This solid-propellant rocket motor by the United Technology Corporation offers extremely high performance, and uses a propellant developed by UTC. Its plastic casing by the Brunswick Corporation significantly reduces its weight, resulting in a mass ratio of 0.94. This motor, which is also suitable for the upper stages of carrier rockets, is 7 ft long and its diameter is 18 inches; it provides a thrust of 600 lb for over half a minute. The propellant load weighs 850 lb.

On June 29th, at Cape Canaveral, the US Navy succeeded in launching three satellites at one and the same time, with one *Thor-Able-Star*. These were the *Transit 4A* navigation satellite (diameter 43 in, weight 175 lb), the *Injun* for cosmic radiation measurement and investigation of auroral phenomena (diameter 16 in, weight 40 lb), and the *Greb 3* designed to measure the variation and intensity of X-ray radiation (diameter 20 in, weight 55 lb). They are orbiting the earth in 104 minutes in a nearly circular path at an average altitude of 575 miles. Unfortunately, *Injun*, and *Greb 3* did not separate from each other, and will therefore not be able completely to fulfil their assigned tasks; *Transit 4A* is, however, functioning as planned. Moreover, this is the first satellite or space vehicle of any kind to carry a nuclear power source in addition to chemical batteries and solar cells. This generator will supply power to various instruments and to two of the four transmitters in the satellite, for a theoretical duration of many years.

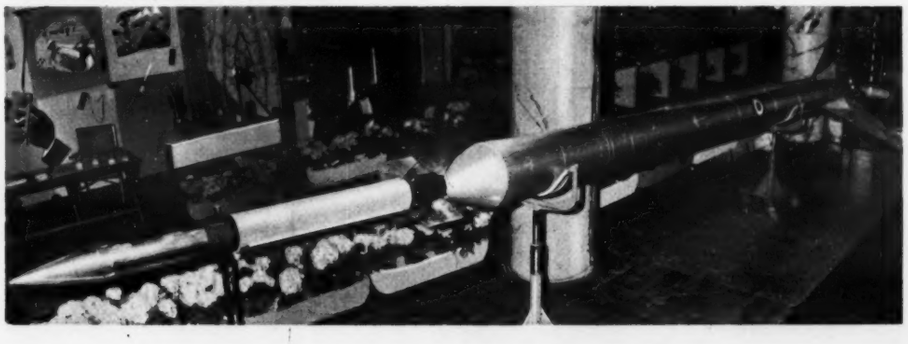
The *Thor-AbleStar* launch vehicle weighed approximately 120,000 lb at launch. The first-stage *Thor* developed a thrust of about 150,000 lb, while the second-stage *AbleStar* had a thrust of approximately 7,900 lb. The overall height of the two-stage booster vehicle is just under 80 feet. It will be recalled that the *Thor-AbleStar* type of launch vehicle was used to place the following satellites in orbit: *Transit 1-B* on April 13th, 1960, *Transit 2A* and *Greb 1* on June 22nd, 1960, *Courier 1B* on October 4th, 1960, and *Transit 3B* and *Greb 2* on February 21st, 1961.

An attempt to launch the next satellite, a new *Explorer*, into a 600-mile high orbit from Wallops Island, Virginia, was a failure. It is reported that the third stage of the *Scout* carrier vehicle did not fire.



Payload of the *Thor-Able Star* launched on June 29th, 1961: *Greb 3* (top), *Injun* (centre), and Transit 4A (below).

Following the lead of Canada, France, and Israel, who have developed and built their own research rockets, Italy is intensifying its activities in this field. The SIAR 2 pictured here at the Rassegna Elettronica Nucleare, in Rome, is a high-altitude meteorological and biological research rocket. Some of the launchings will be carried out on behalf of the Aerospace Engineering School of Rome University (Scuola Ingegneria Aerospaziale Roma = SIAR). The first stage of the rocket is supplied by Contraves-Italiana, while Bombrini Parodi-Delfino has the contract for the second stage and a later third stage. According to information received to date, the first stage reaches a height of almost 10 miles, while the second stage attains about 125 miles.



Also, a launching at Point Arguello, California, on July 10th, of a *Midas 3* reconnaissance satellite ("spy-in-the-sky") ended unsuccessfully. Although the first stage of the *Atlas-Agena B* launch vehicle fired, it did not lift off the ground. Two days later, the *Midas 3* was placed in its planned circular polar orbit. This satellite is equipped with infra-red sensing devices and weighs about 3.500 lb, including the second stage; it circles the earth in 160 minutes at an average height of 1,860 miles, and will theoretically continue to do so for ever.

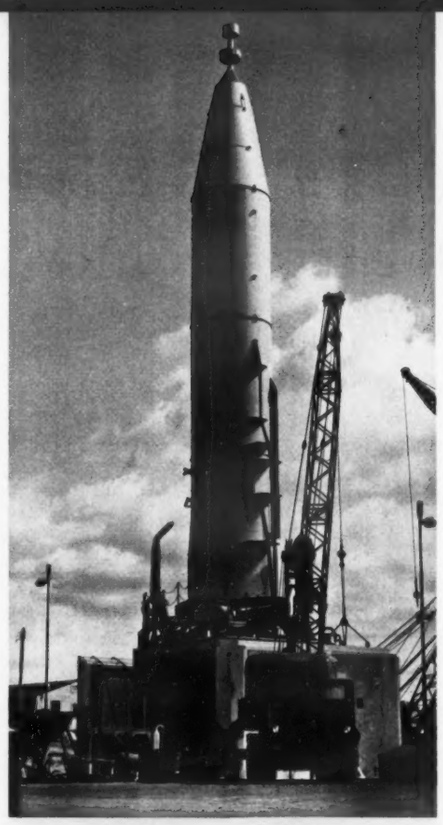
Likewise, on July 12th, there was the successful launching at Cape Canaveral of the *Tiros 3* weather satellite. A three-stage *Thor-Delta* placed it in an orbit whose perigee is 461 miles and apogee 506 miles; its inclination is 47.8° and the orbital period is 100.4 minutes. The weight of *Tiros 3* is given as 285 lb. Unlike its predecessors, this satellite is equipped with two wide-angle television cameras. In addition, the *Tiros 3* also carries new infra-red detection gear. With the launching of this weather satellite, the Santiago, Chile, satellite tracking station commenced operations.

Second Manned Mercury Flight

The *Atlas*-borne *Mercury* research capsule launched on September 9th, 1959 initiated a long series of experiments which led to the first American manned space flight on May 5th, 1961 (see *Interavia* 6/1961, page 794). A second, similar launch with the designation MR-4 *(Mercury-Redstone 4)* was scheduled for July 18th, 1961 by NASA. The capsule was to be manned by Air Force Captain Virgil Grissom, 35, with 40-year old Colonel John Glenn, US Marines, acting as stand-by.

However, due to unfavourable weather conditions, NASA was forced to postpone the launching for 24 hours. Again on July 19th, the launching was delayed due to the cloud cover over Cape Canaveral, at an altitude of 15,000 feet. For satisfactory visual observations of the launching phase of the flight, the required minimum altitude of the cloud cover is about 35,000 feet. Grissom spent nearly three and a half hours cramped in the capsule, as the launching was cancelled only ten minutes before the end of the count-down. As the liquid oxygen tanks of the *Redstone* had to be emptied and cleaned, the launching was scheduled anew for Friday morning, July 21st.

After a thorough preparation and complete check-out, the *Redstone* lifted off its Cape Canaveral platform at 12:22 GMT on July 21st. The capsule successfully separated from the booster and Grissom took manual control as planned,



Test version of the *Atlas F* intercontinental ballistic missile. With the same overall dimensions (80 ft high) as the actual missile, and of the same weight when filled with 28,000 US gallons of water, it is being used at Vandenberg Air Force Base in California to test ground support installations, such as the launch platform elevator in the underground silos. The *Water Bird*, as it is called, will also be used for the training of missile launch crews.

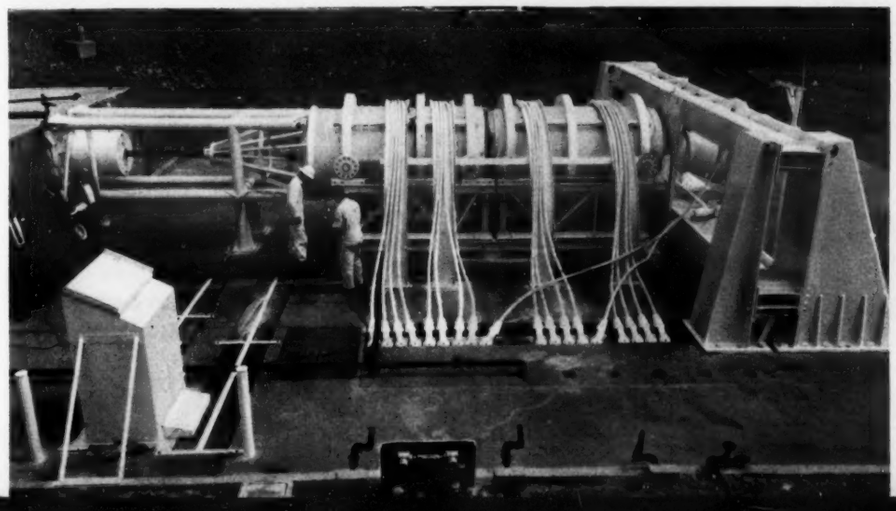
and fired the retro-rockets. During his re-entry into the atmosphere, he registered a deceleration of 10 g. Both parachutes opened successfully, and Grissom made radio contact with the aircraft carrier *Randolph*. The *Liberty Bell 7* hit the water at 12:37 GMT, and shortly thereafter Grissom was lifted aboard the aircraft carrier by helicopter, but the capsule could not be retrieved. It had shipped water through the open emergency escape hatch and was too heavy for the helicopter to lift out of the water; after a short tow, which resulted in over-heating of the helicopter engine, the capsule was released and sank three miles to the ocean bottom.

The following data have so far been made public concerning this second ballistic flight: maximum height 118 miles; maximum speed 5,310 m.p.h.; distance covered 305 miles, i.e. barely 6 miles further than intended.

The MR-4 experiment was practically a repetition of Shepard's flight. Grissom's capsule differed, however, from the *Freedom 7* in the following details: instead of two round 6-in diameter observation portholes, it had a trapezoidal window, 19 in high, 11 in wide at the base, and 7.5 in wide at the top. It also had improved controls (Rate Stabilization and Control System = RSCS), which converted the astronaut's manual movements into electrical signals; these in turn actuated the solenoid valves on the stabilization and attitude control nozzles. Instead of a mechanically-operated emergency escape hatch, the *Liberty Bell 7* had a hatch fitted with explosive bolts, so that it could be blown off in a fraction of a second. The instrument layout was also improved, and new microphones were built into the space traveller's headset. In addition, the *Liberty Bell 7* carried a new radar-reflective inflatable dinghy, which was developed jointly by the NASA Langley Research Center and the Space Task Group, and is 45 percent lighter than the previous type provided. Finally, to reduce capsule vibration as it passes through the transonic speed range during the early phase of flight, the transition mounting on top of the booster was modified (as a result of a successful trial launch with a *Little Joe* on March 18th, 1961).

Model of the annular exhaust nozzle of a General Electric Company liquid-propellant rocket motor with a thrust of 2,500,000 lb. The propellant will consist of liquid hydrogen and liquid oxygen. Under a NASA contract, General Electric recently tested a small experimental version of this motor, which developed a thrust of 50,000 lb.

This close-up view of an Aerojet-General Corporation solid-propellant rocket motor shows the two individual segments, which are easily identified. On the test-stand, this 65-inch diameter motor developed a maximum thrust of 160,000 lb.



The SEREB Agate Research Rocket

As part of the experimental launching of French missiles at Hammaguir, SEREB has also tested the *Agate* research rocket. On the first attempt, the programmed maximum height of 40 miles was attained, and the 880-lb instrument payload was recovered undamaged. The *Agate* was powered by a solid propellant rocket motor developing 4,400 lb thrust at liftoff. The scientific equipment and measuring devices carried aloft consisted, in part, of the following: two long-range data transmitters, a magnetic tape recorder, and an optical recording device. A reduction in the payload to about 132 lb would make it possible to reach a maximum height of about 120 miles. ←←

Today's Undercarriage Design Problems

By A.A.J. Willitt, D.C.Ae., A.F.R.Ae.S., Chief Engineer Dowty Rotol (Arle Court Div.).

The increasing trend towards VTOL and STOL aircraft brings the undercarriage designer new problems of installation and performance. Of particular interest are the installation problems which arise from the use of a single lifting engine of the BS.53 type. The Hawker P.1127 is the first jet lift VTOL fighter aircraft to fly and use this type of engine. A study of photographs of this aeroplane shows how the needs of the engine installation have been catered for by the undercarriage designer.

The massive single engine in the centre fuselage excludes the undercarriage from this stowage region. The efflux pattern of the four vertical lifting jets limits the choice of undercarriage positions, to avoid interference with the jets, and to minimize heating of the landing gear tyres by the hot jets. In general, aircraft with lifting engines are either wingless or have wings of very small area designed for high speed flight which will, as in the case of the P.1127, make wing stowage of the principle undercarriage members out of the question. The diagram shows the plan form relationship of the four undercarriage members and the four jets of the P.1127. A single twin-wheel main undercarriage is located in the rear fuselage close behind the engine, in the neutral plane between the two hot jets. The nose undercarriage is conventionally located in the forward fuselage but, because the engine places the main undercarriage a substantial distance behind the centre of gravity, it carries some 25 percent of the aircraft weight. To give lateral stability, light auxiliary undercarriages are provided at the wing tips and are faired into the wingtips when retracted.

This bicycle undercarriage layout is not in itself new, though it has been used operationally on only three modern aircraft of the Western world. These previous examples were different in that the two fuselage undercarriages shared the static weight almost equally, whereas in the P.1127 only 25 percent of the weight is carried on the forward undercarriage. With a 50/50 weight distribution the touch-down attitude of the aircraft has proved critical, in that a hard touch-down on the rear undercarriage pitches the aircraft forwards, and slams the front undercarriage down at a higher velocity than can be economically designed for, and a heavy touch-down on the leading undercarriage causes an unstable porpoising of the aircraft which can only be controlled by flying off again. The 25 percent-75 percent distribution allows the P.1127 to land with the same wide tolerance of attitude as is experienced with conventional undercarriage layouts.

Details of the unconventional undercarriage designed by Dowty for the Hawker P.1127 VTOL fighter can be seen in this photo. The tandem main unit is situated behind the engine and two light outriggers support the wing tips.

Nose Undercarriage Steering

For all types of aircraft, nosewheel steering has assumed an increased importance, to bridge the control gap at speeds below which the flight controls are effective. Improved directional control below flying speed is essential to meet new operational requirements of cross wind landings, particularly when using a braking parachute.

Usually nose undercarriage steering, differential wheel brakes, and possibly differential engine control, are available to the pilot but, with tandem undercarriages and a single engine, the Hawker P.1127 has only nose undercarriage steering for directional control at speeds below rudder effectiveness, and hence nosewheel steering assumes a new importance. New standards of accuracy of directional control have been achieved and an extremely high standard of reliability is essential. The 25 percent weight distribution on the nose undercarriage ensures sufficient nosewheel tyre traction on wet surfaces.

Stability During Lift-Off

During a vertical lift-off, when the aircraft is in transition from standing on the landing gear to being airborne, it is important that the aircraft has a very high roll stiffness at all stages, otherwise inclination of the jet together with the moment due to the lateral C.G. shift can easily demand lateral hovering control system forces which are much larger than those required for full free flight. If such

forces are not available to level up the aircraft, it will track off sideways until airborne, a fault which can be observed from the cine records of experimental VTOL types, particularly during cautious early lift offs.

Undercarriage Weight

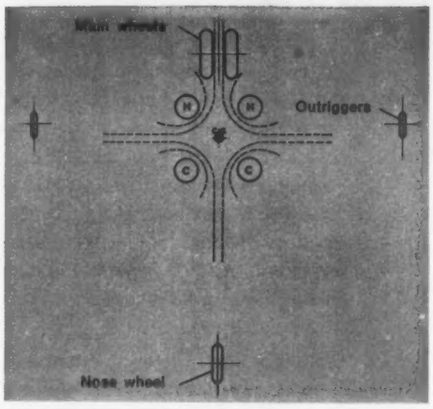
With all aircraft, minimum undercarriage weight is of considerable importance. In the case of vertical takeoff aircraft, it is of supreme importance in view of the small payload margin which present engines permit. To achieve this weight reduction, the undercarriage designer is using new materials; ultra high tensile steel (270,000 p.s.i. ult.) and titanium (170,000 p.s.i. ult.) together with even more sophisticated structures and mechanisms to minimise weight. His attention is also being directed to design requirements for undercarriages which have grown up around conventional installations, and which do not necessarily apply directly to unconventional aeroplanes and undercarriages.

Vertical Velocity Requirements

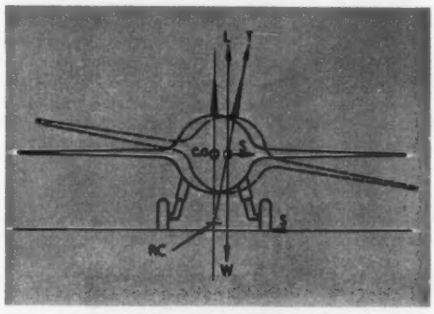
Aircraft undercarriages are primarily designed to meet vertical velocity requirements which have been established over many years, and, for most conventional forward landing, aircraft have been stabilised at around ten to eleven feet per second. This requirement, coupled with well established design rules, produces undercarriages having an acceptably low failure rate.

The design velocity has been derived from the vertical velocity due to the slope of the approach path, plus an additional velocity component due to the pilot's deviation about the mean approach path. Statistics show that this assumed velocity is rarely used, thanks to the pilot's ability and natural instinct to flare out the approach path just before impact. By so doing, he achieves impact velocities in the order of 2—4 feet per second under normal visibility conditions and 5—7 feet per second under bad visibility. We have therefore, in the 11 feet per second requirement, a hidden factor of strength which contributes towards an acceptable undercarriage fatigue life for airline use, despite the low strength factors used in design.

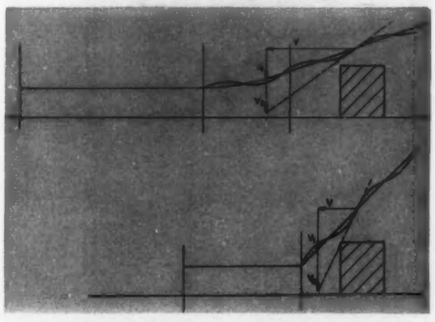
For STOL landings, the aircraft is designed to have a very steep approach path which, even with lower forward speeds, seems to suggest a design vertical velocity for the undercarriage of 13—15 feet per second. Here, flare out is an undesirable wastage of the landing run, since wheel brakes or other devices cannot be used until the aircraft is on the ground. The ideal STOL technique is to fly the aircraft into the ground down a steep approach path, which is in many ways similar to a method with which we are already very familiar, i.e. landing on an aircraft carrier. Carrier borne aircraft are designed to be flown into the deck, at a predetermined spot indicated by the mirror glide path.



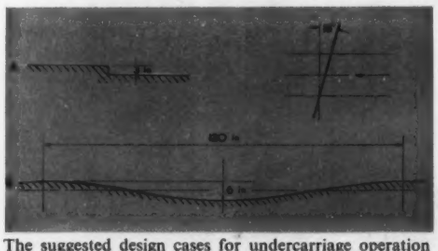
The undercarriage disposition and jet pattern for four vertical jets. The two hot jets from the rear nozzles (H;H) and the two cool forward jets (C;C) are disposed about the aircraft's centre of gravity.



A diagram of the de-stabilizing moment due to weight and engine side thrust component. If the lateral hovering control forces in a VTOL aircraft are insufficient at lift-off, it will tend to track sideways with a resulting sideload on the undercarriage. The following abbreviations are used in the diagram: RC – roll centre; CG – centre of gravity; L – lift vector; T – thrust vector; W – weight vector.



A comparison of the undercarriage vertical velocity requirements for a conventional and a short field landing. In the short landing, owing to the absence of flare-out, the distance V is considerably reduced, resulting in an increase in the vertical velocity V_1. The component V_2 represents the additional velocity resulting from the pilot's deviation about the mean approach path.



The suggested design cases for undercarriage operation from semi-prepared surfaces. A. A 3″ step in the runway profile; B. A sine wave surface of 6″ total amplitude and wave length not less than 120″.

Statistics show that average impact velocities are a high proportion of the design value, and it is to be expected that STOL aircraft will, on average, also use a substantial proportion of their design vertical velocity, hence the hidden factor which has contributed to a satisfactory fatigue life will disappear. This is not a very important problem for short-life military aircraft, but is of considerable importance for the commercial aircraft.

In considering the requirements for aircraft landing vertically, we have as background experience the well-established helicopter. This in general is designed for lower vertical velocities than forward landing aircraft, because the pilot has the ability to check the descent at any stage. In fact, some smaller helicopters have only nominal undercarriages of steel tubes and without wheels. Limited experience with jet lift aircraft suggests that these also make contact with the ground at a very low velocity.

Rough Ground Operation

Military planners desire to link the STOL aeroplane with operation from semi-prepared airfields. These rough airfields are by their very nature difficult to define in a way that enables the undercarriage designer to give a quantitative statement as to the performance of the undercarriage. Existing undercarriages have in general been designed for operation from smooth runway surfaces, and even on these comparatively smooth surfaces, pilots and passengers are well aware of the harsh transmission of runway imperfections to the airframe. These undercarriages have been designed primarily as landing energy absorption devices with little regard for taxying comfort. The movement of the oleo strut is heavily damped to be effective at closing velocities in the order of ten feet per second, but it is so heavily damped as to be unresponsive to input frequencies from the ground above a few cycles per second. Hence the tyre, which has little or no damping, and whose behaviour is independent of frequency, has to take care of all high frequency ground roughness. Over the years the progressive stiffening of tyres, as pressures have increased and the sectional depth decreased, has produced a correspondingly harsher ride on later aircraft.

In the absence of any unified definition of running surface roughness, the following arbitrary standard is suggested for undercarriage design. Firstly, a step in the runway profile 3″ high and secondly, but not together, a sine wave surface of 6″ total ampli-

tude and wave length not less than 120". In both cases the disturbances to be considered at up to 15° to the direction of motion." These suggested disturbances apply only to the landing run proper, since, by reducing speed appropriately the aircraft can negotiate a much rougher taxi-way.

To meet such a requirement with a conventional undercarriage, requires tyres having a working stroke from the static position larger than the sharp edge disturbance, so that it can pass through the tyre without deflecting the oleo strut. The instantaneous reaction will be appropriate to the deflection, which, if all the available tyre stroke is used, will be in the order of 3g. It will be appreciated that the sinusoidal wave form needs a more elaborate analysis, and here the problem is that without help from the oleo strut, the mass of the aircraft mounted on the undamped tyre will, at some frequency, go into resonance and become out of phase with the input disturbance, thus causing the wheel hub to bottom on the wave crests. This situation is obviously greatly eased if the damping of the oleo strut is relaxed to allow the strut to respond to comparatively high frequencies and this can be done in two basic ways: either by allowing a proportion of the strut stroke to be only lightly damped as is the tyre, but this necessitates additional stroke length to achieve the required landing energy absorption and reduces the efficiency of the undercarriage, or, alternatively, by making the strut damping controllable either automatically or manually for taxying conditions.

It is envisaged that future commercial aeroplanes will have controllable damping characteristics of the undercarriages. This will optimise the ground ride of the aircraft to the benefit of the aircraft structure and the passenger comfort, and at the same time make the maintenance of the runway surface less critical.

Soft Ground Operation

Again, military planners talk of soft ground in the same breath as unprepared surfaces, and again without definition of the term soft ground. As the designers of military ground vehicles have discovered, soft ground can be so soft as to need tyre pressures as low as 1 p.s.i. to prevent the vehicle becoming bogged down. Clearly, no practical aeroplane can be fitted with a wheel-like device which will reduce tyre pressures to the order of 1 p.s.i., not even by the fitting of caterpillar track-type arrangements. Tyre pressure is not by itself a true criterion, since, if the tyre pressure is greater than the ground surface will stand, the ground will yield and the tyre will sink until sufficient flotation area is achieved. Making use of this flotation characteristic of tyres enables the aircraft designer to use a higher tyre pressure than the nature of the ground would suggest but as will be appreciated, a slight reduction in ground support can cause the wheel to sink up to the axle. It is improbable that aircraft designers will be able to provide sufficient space or weight to achieve tyre pressures lower than 35 p.s.i. on transport aircraft, or 90 p.s.i. on attack aircraft.

The 100-ton drop test rig at the Cheltenham works of Dowty Ltd. This machine is capable of testing undercarriage units for aircraft of 400,000 lb AUW. The effect of wind or jet thrust can be simulated on the machine and it is equipped with wheel rotation gear to produce all the combinations of dynamic loading on a multi-wheel undercarriage.

Automatic Brake Control

With the emphasis on lighter undercarriage structures and the use of higher strength materials, attention must be given to undercarriage and airframe stiffness, particularly where automatic on/off brake control is fitted, or where the wheel brakes give a substantial torque fluctuation per revolution. The application of an alternating dragload which explores a wide frequency range can easily lead to resonance, or further, to coupling between a mode of the undercarriage and the operation of the automatic brake control system. If such coupling occurs, a large energy input from the ground to the undercarriage can take place, resulting in structural failure analogous to a wing flutter failure.

Undercarriage Life

The modern commercial aircraft is expected to have a ten year useful life and in this period fly some 30,000 hours. Long-range aircraft averaging two hours a flight will expect to make some 15,000 landings and take-offs without replacement of major undercarriage structure. Short-haul aircraft of the Fokker/Fairchild *Friendship* type operate at as high as 2½ landings per hour. At the moment a number of the Dowty equipped *Friendships* operating in the USA. have each exceeded 13,000 landings in two years of operation.

To achieve such a standard of structural integrity, it is obvious that the undercarriage designer must rely upon the design data obtained from the laboratory fatigue testing of complete undercarriages and detail auxiliaries to attain this long life performance. →→

Modern Aircraft Tire Development

By L. S. Randall, Principal Engineer Aircraft Tire Development, The Goodyear Tire and Rubber Company, Akron, USA

As announced in the June issue of Interavia, *we are continuing the series on undercarriages, brakes and tyres with the following article written by a tyre manufacturer. Readers who have already had the opportunity to see a modern supersonic fighter scorch down the take-off runway at 220 m.p.h., or to be present at the touchdown of a Boeing 707, will agree that the tyre problem is, in the truest sense, a burning one. Even the Goodyear engineers might well find cause for consternation in the most recent specifications of the Air Force and the aircraft manufacturers. Being concerned with the development of aircraft tyres at Goodyear, the author appears particularly well-qualified to initiate us into the difficulties of his business.* *The Editors.*

Fig. 6: Under certain conditions, at high circumferential speeds, standing waves appear. These produce strong flexural effects which lead to overheating and eventual failure of the tire.

In earlier times, when aircraft ground speeds were hardly in excess of 160 m.p.h., tire design was more or less a routine matter. Problems requiring special attention, such as tread and carcass separation and bead failures, seldom arose. The tire manufacturer's principal preoccupation was to extend tread life and increase the number of times retreading could be undertaken—in other words, more a matter of improving the economics of tires than of eliminating premature failure.

However, the ever-increasing speed of aircraft —both in the air and on the ground—brought the necessity of keeping the tire structurally intact during its entire expected tread life more and more into the foreground.

The Problems

The tire manufacturers were, and in a number of cases still are, faced with two main problems. First, the adhesion of the tread to the tire body. Second, the structural inadequacies of the tire body. These are difficult enough under normal temperatures, but are greatly magnified at abnormally high ambient temperatures.

The Factors

To put the problems in perspective, the following *Table 1* gives comparative data for a fighter aircraft tire and an automobile tire of the same overall dimensions. As clearly emerges, aircraft tires are assigned a much higher load rating than a ground vehicle one of the same size and rating.

Table 1

Tire Characteristics	Aircraft	Automobile
Size	25×6.75	6.50×13
Overall diameter (in)	25.0	25.0
Section width (in)	6.50	6.50
Ply rating	18	4
Load rating	13,000	835
Inflation (lb)	300	24
Deflection (%)	32	17
Max. speed (m.p.h.)	275	100
Tire "efficiency" (lb load/lb tire)	400	40

The ply rating ratio for the aircraft tire is thus 4½:1, the load rating ratio over 15:1, and the load factor (tire efficiency) 10:1. The higher load rating for the aircraft tire can however be achieved only by permitting it to deflect much more than that of the ground vehicle. In our table, deflection of the former is some twice that of the latter and this ratio is often 2 ½ to 3 at identical size. The higher rating is made possible by the fact that the aircraft tire is called upon to operate only intermittently. At its rated load and inflation, under automobile conditions of continuous running, it would quickly break down.

Over the years, there has been an increase in the "continuousness" of operation, owing to longer taxiing distances, longer takeoff and longer landing rolls, without any relaxation in the basis for rating tires.

Speed

There are many factors which create modern development problems, but if we had to place one at the top of the list, it would probably be speed. *Fig. 1* is representative of the increase in ground operating speeds over the years since World War II, as applicable to popular Air Force aircraft. The early jets had maximum ground speeds of 120 m.p.h. By 1953, these had increased to 200 m.p.h., and today there are requirements of 300 m.p.h. and more.

Since the parts of a rolling tire are continuously changing direction, it is axiomatic that the forces which are necessary to change the direction of these parts depend upon the speed and are related to it exponentially. For example, doubling the speed will quadruple the stresses.

Deflection

The relatively high deflection, which is, as already mentioned, basic in the rating of aircraft tires, is a considerable handicap in the development of high performance tires. The forces created in a deflected, rolling pneumatic tire are many and complicated, particularly those acting on that portion passing through the ground contact area.

For better understanding of the somewhat complicated phenomena which arise when an elastic tire is rolling through the contact area, we begin with the simplest case (*Fig. 2*) of a point (P) on a solid rolling wheel—a plain wheel, which does not deflect. As the wheel makes one revolution from position 0 to position 2, point P traces the cycloidal path (LOCUS P), cusps being traced as point P on the periphery of this undeflected wheel passes through ground contact.

A rolling pneumatic tire, however, is not like this simple wheel, and can, in a sense, be com-

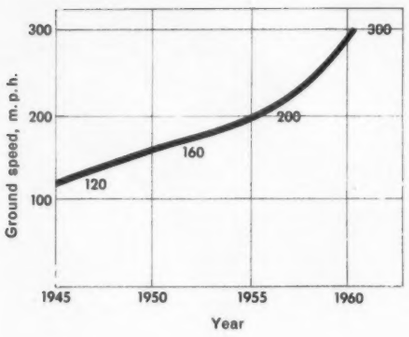


Fig. 1 : Increase in operational ground speeds from 1945 to 1960.

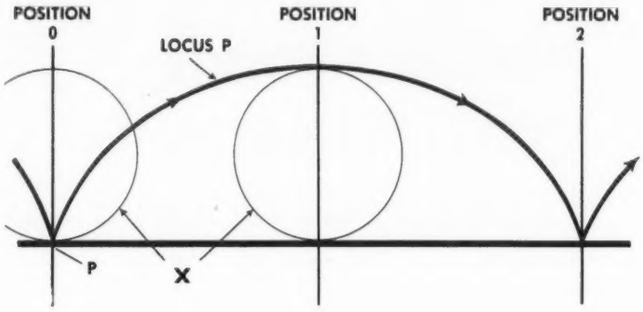


Fig. 2 : A point P on the circumference of a plain rolling wheel describes a cycloid (locus P). X designates the plain rolling wheel.

pared with a railroad car wheel rolling on a rail, which is depicted in *Fig. 3*. The inner circle—radius "L"—represents the rolling surface of the wheel and the outer circle—radius "R"—the flange of a wheel. Let us now consider a point "P" on the outer edge of the flange. In making one complete revolution from position 0 to position 3, point "P" (shown in position 0 at the bottom of the wheel) traces the path marked "LOCUS P." Note that, unlike the ordinary rolling wheel, a loop is traced as the wheel passes through the ground contact. The entire path is known as a looped trochoid.

Fig. 3 thus gives an analogy with a rolling elastic tire, "R" being the undeflected radius, and "L" the deflected or loaded radius as the tire goes through contact. We can now look at position 1 and imagine a point on the undeflected surface of the tread which has arrived at "A", and is ready to enter the contact. If this point could do as it pleased, it would follow the loop ABC as the wheel moves the distance "D" from position 1 to position 2. However, it obviously cannot do this, and is forced to follow the straight line AC along the road surface.

The forces that prevent this point on the tire periphery from describing its natural path and compel it to follow a straight line are proportional to the accelerations of the point on the loop of the trochoid.

Offhand, it may be difficult to imagine this, but a point on the tread is slowed down from the point of entering the contact area to zero at the center of contact, and speeds up to take its place on the undeflected tire beyond contact. The accelerations, and hence the relative forces of a point in passing through the contact, are very high and even change direction. It can be seen that, as the deflection is increased, the trochoid loop becomes greater; in other words, the tread is compelled to depart further from its natural path, resulting in even greater stresses in the contact area.

Further complicating factors affecting the force system in the contact area include the tread curvature, which causes points across the width of the tread to enter the contact at different times. Also, the carcass beneath the tread has still different radii of curvature. Thus, each of the various points across the tread and down through the carcass has its own peculiar acceleration through the contact. Furthermore, there is the action of ordinary centrifugal stresses.

Table 2

Speed (m.p.h.)	G's	Force exerted on 1 oz tread (lb)
100	500	33
200	2000	130
300	4500	300
400	8000	528

Table 3

Ambient Temp	Time of Exposure
275°F	90 minutes
325°F	30 minutes
350°F	10 minutes

The foregoing adds up to a multiplicity of shear, tensile and compression stresses and a general squirming in the contact area. These tend to separate the tread and ply components and also manifest themselves in heat which is, of course, an additional stress. Unfortunately, in all of this, speed has an exponential effect.

Centrifugal Forces

In addition to the stresses described in the preceding paragraph, the whole tire is, like any rotating body, subjected to the ordinary centrifugal forces. *Table 2* on this page shows the magnitude of these forces in G's and the forces exerted on one ounce of tread for a tire of 30 in. diameter, at various speeds. It will be noted that these forces increase as the square of the speed.

Coupled with the stresses incurred in passage through the contact area, these forces, particularly in the higher speed ranges, closely approach or exceed the safe limits of contemporary materials and designs.

Heat

Heat is the arch-enemy of rubber. As the temperature of a tire rises, the stress and fatigue resistance of the rubber and fabric components diminishes.

The sources of heat are (1) brakes, (2) heat generated by the flexing during roll, and (3) high wheel-well temperatures resulting from supersonic airplane speeds.

The degradation of the nylon used in today's tires is typically shown in *Fig. 4*. At about 360°F, the nylon loses half its room temperature tensile strength. Above 400°F, the strength drops off

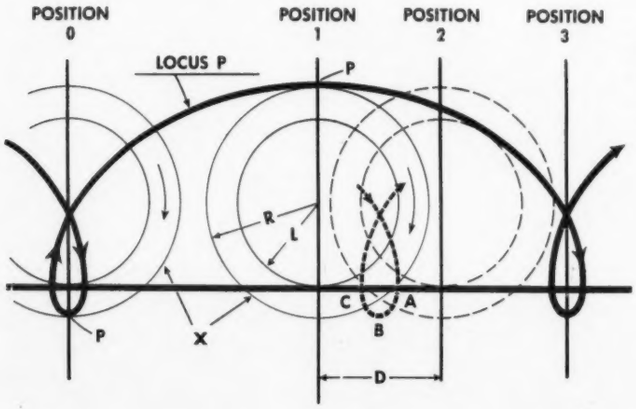


Fig. 3 : A point P on the rim of a flanged wheel (radius R) describes, in one revolution (from point 0 to point 3) a looped cycloid. X designates the flanged rolling wheel.

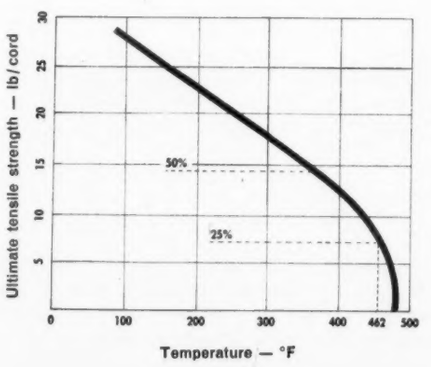


Fig. 4 : Reduction in tensile strength of nylon cord with increasing temperature.

very rapidly until at about 480°F nylon becomes plastic and loses its strength completely.

The higher temperatures not only degrade the materials, but also produce an increase in tire pressure and stress in the cords. Thus, the safety factor against cord failure is reduced even more rapidly than indicated by *Fig. 4*. A similar effect of temperature on the tensile strength of the rubber compounds available today is shown at *Fig. 5*.

To a certain degree, rubber compounds are fairly good insulators and, for a limited time, they do afford some protection to the inner components of the tire against heat from an external source. In other words, for relatively short periods of time, tires can withstand higher levels of temperature and survive more than two or three landings. For example, based on some exploratory test work performed by the US Air Force on 26×6.6 contemporary fighter tires, the limits of exposure time at different environmental temperatures found are shown in *Table 3*, the basis for the limit being the ability to make 10 simulated landings without failing.

Standing Waves

With certain configurations, and under certain conditions of inflation, load, and speed, so-called " standing waves " will result.

Fig. 6 shows this phenomenon, as observed on a 24×7.7 size tire being tested in the laboratory at 250 m.p.h., and the extreme amplitude of the wave can be clearly seen. There are three or four such waves around the tire, which means that at a peripheral speed of 250 m.p.h., its tread is being flexed 12,000 to 16,000 times per minute. This naturally generates considerable heat and can result in premature and sudden failure. The standing wave condition is worse as the speed and deflection increase, and as the inflation pressure decreases. It is also worse for small diameter tires and those of relatively high cross-section.

Inflation Pressures

The extent to which inflation pressures have increased over the years is shown by the graph at *Fig. 7*, which is based on normal pressures for land-based aircraft. In the case of carrier-based aircraft, as used by the US Navy, the same tires require up to 60 percent over-inflation in order to prevent the wheel and tire damage to which severe impact loads, due to arrested landings, give rise.

Generally speaking, the upward trend in pressure can be attributed to the fact that, whereas the weight of aircraft and tire loads have been constantly increasing, modern designs have kept down the space allowance for the wheels.

Table 4 on this page compares the load and inflation requirement of a 30×7.7 tire in 1960 and 1950.

The effect of increased pressures on tire design is to require more plies and more bead wire. At the high pressures, this results in great bulk and, accordingly, in " hotter " running. Furthermore, with the many and varying cord paths in a multiple ply tire, it becomes extremely difficult to maintain uniform stresses throughout. The effect of this is to localize stresses which, coupled with

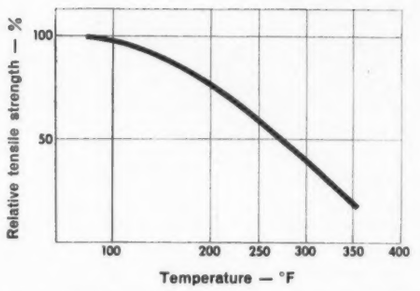


Fig. 5 : Tensile strength of rubber vs aging temperature (8-hour test duration)

the added heat, can lead to ply separation and tire failure.

Tubeless Tires

The introduction of this type confronted the manufacturers with a number of problems, the most serious being the natural diffusion of air through the carcass.

Air diffusion also occurs with tubes, but here the air can escape through the wheel or under the bead. In the case of tubeless tires, however, the air seeps through the carcass and results in an accumulation of pressure throughout the plies and other components, thereby increasing the tendency towards separation.

Load and Distance

Having so far mainly considered individual factors, such as speed and loading, we shall now touch briefly on some of the problems

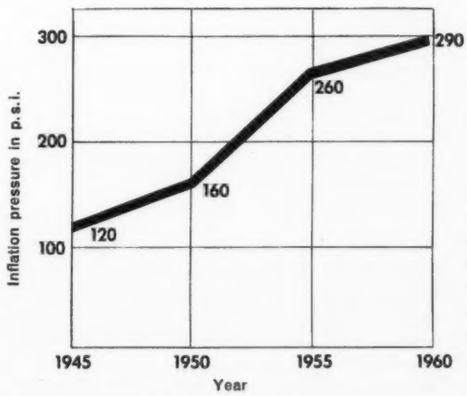


Fig. 7 : Increase in fighter aircraft tire pressures.

Table 4

	1950	1960	
Ply rating	12	22	
Based	*Land*	*Land*	*Carrier*
Static load (lb)	12,000	21,300	21,300
Inflation (p.s.i.)	165	325	425
Impact load (lb)	(no requirement)		100,000
Index static load	100 %	178 %	178 %
Index inflation	100 %	197 %	258 %

resulting from the joint action of several factors. The manner of loading has also changed unfavourably as far as tires are concerned.

During a typical takeoff run, the increase in wing lift for the older model aircraft was such that the tire loads decreased to very low values at the point of takeoff. In the case of modern aircraft, however, these loads are relatively much higher at the point of takeoff. Typical of the commercial jets, tire loads at the takeoff point are approximately 60 percent of the static load. Certain other high performance aircraft take off with " negative lift," and thus exert tire loads at take-off which exceed even the static load.

The roll distance during all ground operations, taxi, take-off, and landing, is of utmost significance. Due to their high deflection, aircraft tires heat up rapidly under prolonged rolling. In severe cases, this can result in rupture and blow-out. Whereas older airplanes taxied less than a mile and took off in less than a mile, modern aircraft may taxi as much as five miles to the take-off point and then require two miles to take off. Should it be necessary to reject a takeoff, then considerable additional rolling occurs without an opportunity for the tires to cool.

Approaches to Solution of Problems

As indicated early in this article, adequate adhesion of the various components is, or has been, a general problem with high performance tires. (We refer especially to nylon, since virtually all contemporary aircraft tires are constructed of such material).

The approach to the adhesion problem is (1) to improve the adhesion values of the component materials themselves and/or (2) to reduce localized stresses by changes in design.

Adhesion weaknesses may occur either at the surface of the individual tire cords, between the layers of the compound components, or within the compound itself. Thus, development emphasis is placed on both the " dip " (cement or adhesive) with which the cords are impregnated, and on the formulation of the rubber compound itself. This involves trying out innumerable combinations of elastomers, polymers, carbon blacks, curing agents, softeners, accelerators, and the other ingredients that go to make up rubber compounds and fabric adhesives. Emphasis is also placed on the cord itself; for example, changes in the surface finish of the cord have resulted in better adhesion.

A considerable amount of screening of materials is done by testing the materials themselves before evaluating them in a tire. It must be determined that changes which improve the adhesion characteristics of a compound or dip do not adversely affect its other properties such as fatigue resistance, tensile strength, elongation, and aging.

Vulcanization is a factor in the adhesion qualities of the tire components, and explorations of numerous combinations of vulcanization time, temperature, pressures and heat distribution have resulted in improved adhesion and more resistance to separation.

Among the design factors which have been found advantageous or necessary in overcoming adhesion inadequacies are the following.

● Tread Thickness

It is perhaps obvious that the thickness or mass of the tread is a factor in the ability of the tread to remain intact at high speeds. Centrifugal force, which tends to separate the tread from the carcass, is proportional to the tread mass or thickness. Thus the strength of the tread adhesion dictates thickness of the tread for a given tire size and rolling speed.

● Tread Reinforcement

It has been found that adding reinforcement to the tread in the form of layers of cord fabric substantially aids in keeping the tread intact. In fact, the advantage is sufficient to permit the use of treads thicker than would normally be safe without such reinforcement. For example, whereas a skid depth of .33″ is considered maximum for safe operation with an all compound tread, a skid depth of .40″ (20 percent increase) is possible if the tread is reinforced with fabric. The advantage of reinforcement is even greater with shallower skid tires. Variations in the amount, kind, and arrangement of the reinforcement are included in this aspect of development exploration.

● Tread Pattern

Certain tread patterns have been found more beneficial than others from the standpoint of tread retention. For the most part, ribbed type patterns are utilized on aircraft tires primarily for uniformity of wear, and improved coefficient of friction, although this does not preclude the use of other patterns. The number and location of the tread ribs or grooves is significant, depending on the service conditions involved. Experimentation with tread patterns must include not only adhesion qualities, but also traction on wet runways, cut and wear resistance, chunking, and chipping resistance.

● Tire Shape

Tire shape is a very important factor in overcoming problems of tread and carcass separation. "Aspect ratio" (i.e. the ratio of the tire section height to its section width) is a term used to describe or classify a tire's shape. As operating speeds have increased, there has been a trend to tires of lower aspect ratio. Aspect ratio is governed by the ply angles (these are the angles the tire cords make with the circumferential center line). Lower cord angles result in a lower aspect ratio, and in tires which are more resistant to distortion at high speeds. For example, the high speed "standing wave," described earlier in this article, can be eliminated by selecting a lower aspect ratio. Whereas for "ordinary" tires this ratio lies in the range of .80 to .90, for high performance tires the trend in configuration has been towards lower ratios, in some cases down to .65. There are however certain disadvantages to low aspect ratios, and therefore experimentation continues to find the optimum shape tire for a specific application.

● Cord Design

The cord is obviously a most important component in the make-up of a tire. It is important not only from the standpoint of its static strength, but also in regard to overall durability, including its effect on component-to-component adhesions which, as stated previously, are a major problem in qualifying high performance tires. There are many variations in cords and cord properties which the engineer must consider in connection with improved adhesion and the general design of a tire. Such cord variations and properties include:

1. The basic fiber itself (this is commonly nylon, but there are different kinds of nylon). Research continues on various nylons and other new fabrics such as polyester, vinyl, HT-1, and polyolefin.
2. Yarn size or weight. "Yarn" refers to the thread which is formed by assembling many fibers or filaments of the basic material. Its size or weight is expressed in grams per 9,000 meters of yarn. A currently common nylon yarn is 840 denier (denier = 0.05 gram).
3. Cord construction. This refers to the number of yarns and the manner in which they are combined to make the cord. Two or more yarns may be twisted together to form a cord. The construction and "twist" (turns per inch) of the single yarn and plied yarn are variables which affect the cord properties.
4. Cord strength, i.e. load necessary to rupture cord.
5. Elongation, i.e. increase in length when subjected to loading.
6. Growth, i.e. permanent set in cord under operating load.
7. Fatigue resistance, i.e. ability to withstand failure under repeated cycles of stressing.
8. Adhesivity, i.e. affinity of the cord for the bonding material.
9. Heat resistance, i.e. ability of the cord to retain its strength and fatigue resistance at elevated temperatures.

The cord properties are further affected by the processing to which the raw cord is subjected. Processing consists of stretching the cord under certain conditions of time, temperature, and tension, and simultaneously dipping the cord in adhesive. The tire cord engineer uses variations of this processing in the development of better cords and fabrics.

The spacing of the cords in the tire plies is also a factor which is investigated in connection with adhesion problems. Within limits, fewer cords per inch are beneficial from an adhesion standpoint, but of course this results in a reduction in ply strength which must be kept within safe limits.

Other design factors that the tire engineer investigates where there are adhesion problems include:—

1. The amount and kind of compound between the cords and between the plies.
2. Actual number of plies.
3. Use of auxiliary fabric reinforcements.
4. Insulation of raw fabric edges.
5. Arrangement and location of ply endings.
6. Amount and distribution of bead wires and bead reinforcements (in cases of adhesion problems in the bead area).

*

High Temperature Tires

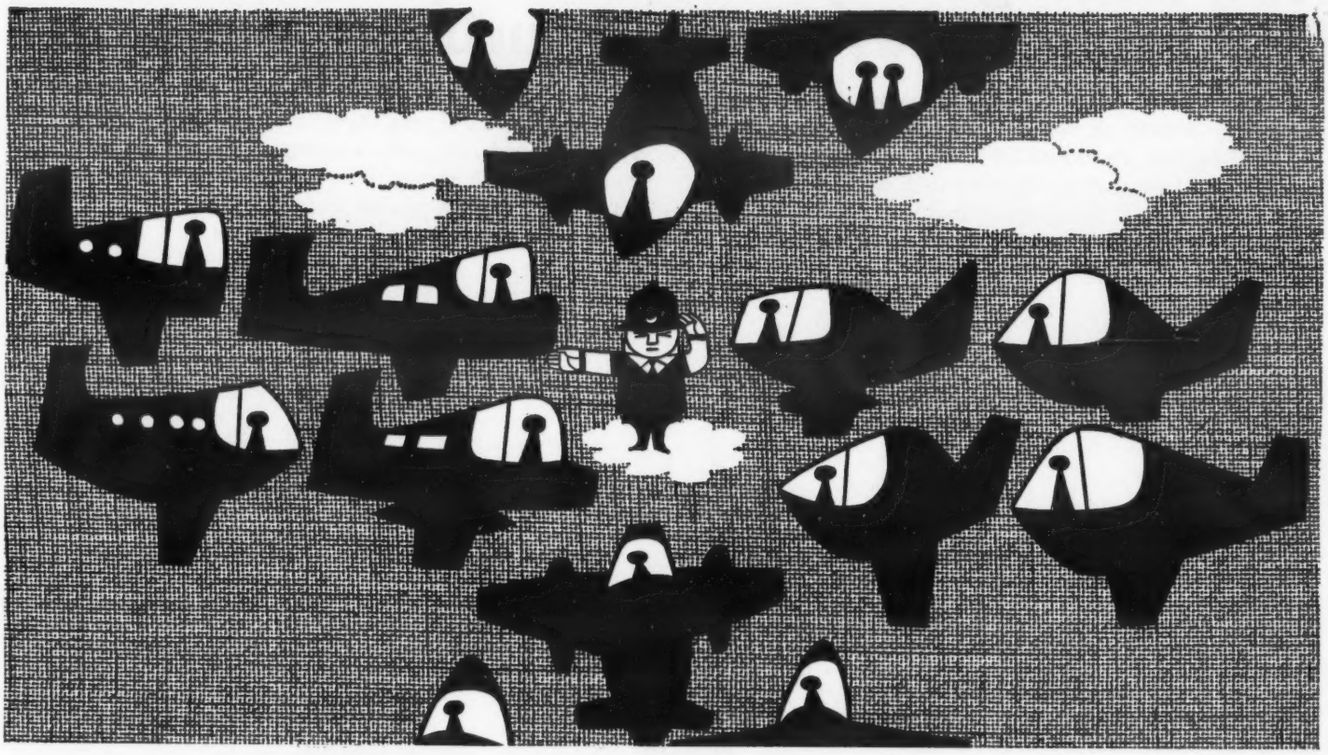
As indicated previously, there are limits of temperature which should not be exceeded when using contemporary tires. The temperature limits depend upon the time of exposure and other conditions, but are not especially high compared with the ambient values of 600° to 800°F for several hours exposure which are expected with supersonic airplanes. While some improvement in the high temperature qualities of textile-constructed tires (nylon, HT-1, etc.) can probably be accomplished, it does not presently appear that such improvement will keep pace with foreseeable severe temperature requirements. To meet the latter, wire will probably have to be adopted as the basic carcass material, and development work has been and is proceeding accordingly, with emphasis being given to wire-to-compound adhesion systems. At the same time, experimentation continues to determine safe temperature limits for textile tires. Should tires not be developed in time to meet the "natural" temperature requirements, it will then be necessary to provide cooling and/or suitable insulation to avoid exposure to unsafe temperature conditions.

*

The solution of many of the problems encountered with aircraft tires is seldom accomplished by one or even a few individuals. Solutions are arrived at as the result of cooperative team effort, both within the tire manufacturing organization and by the suppliers of the basic materials.

At Goodyear, for example, there are (1) tire design engineers experimenting with more or less contemporary designs, (2) development compounders experimenting with conventional compounding materials, (3) a group of tire cord engineers who concentrate on improvement in the cord or fabric components, including cord adhesives, (4) tire design researchers, who investigate unconventional designs for tires, (5) pure researchers, who explore the unknown and unconventional materials, and (6) process development engineers. Beyond this, vendors of the basic materials conduct research and contribute to improving the state of the art.

In spite of the rapid advance in the development of aircraft, with the accompanying increase in the severity of tire requirements, many tire problems have been solved, and high performance airplanes are flying with little incidence of tire failures. With the many avenues of approach and with the know-how, experience, and ingenuity of cooperative engineering teams, we are confident that satisfactory solutions to current and future problems will be found. ◆◆



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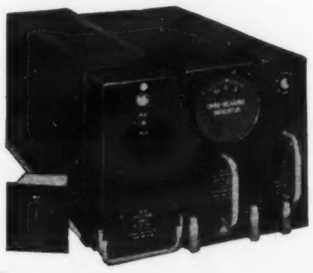

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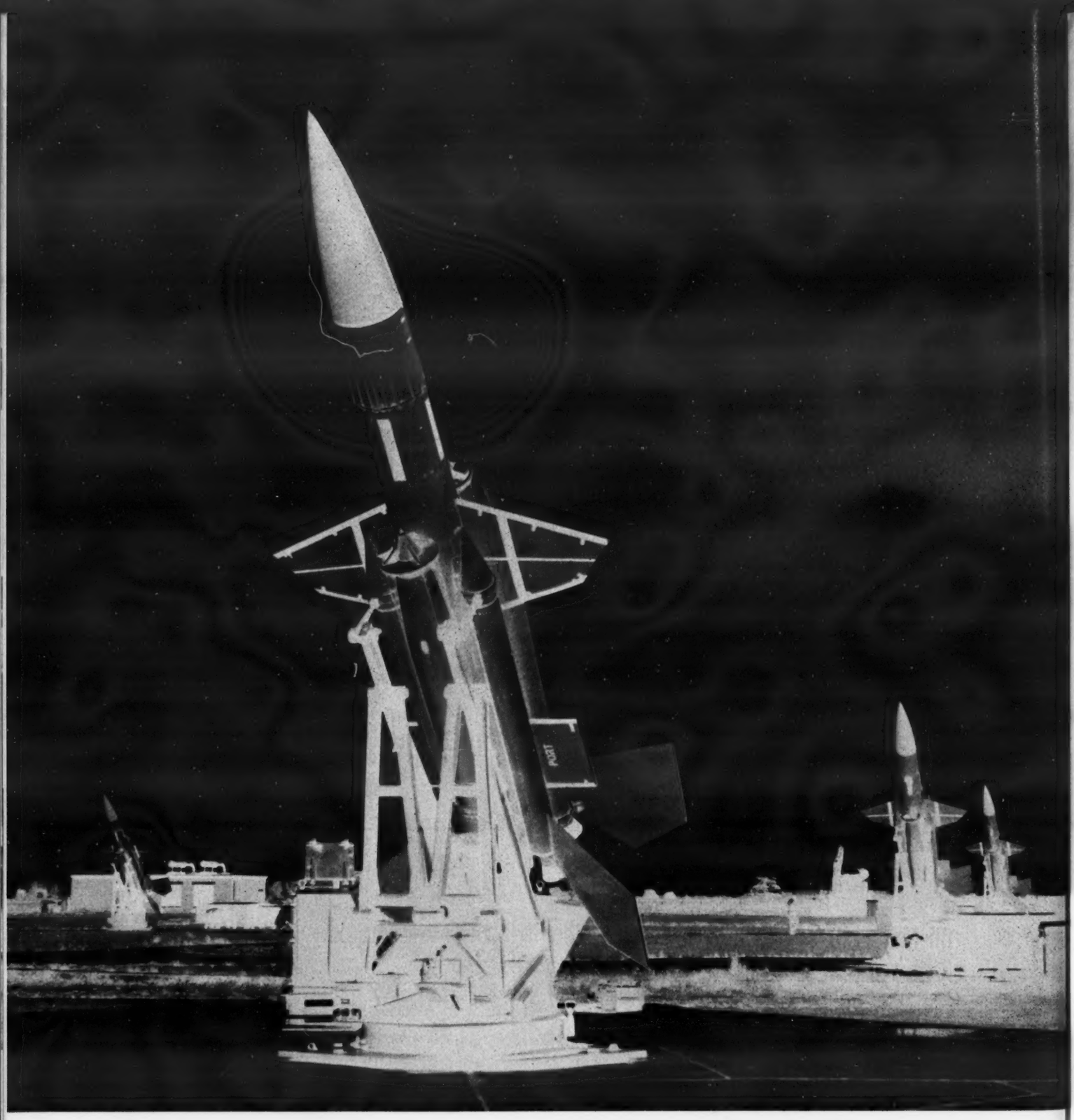

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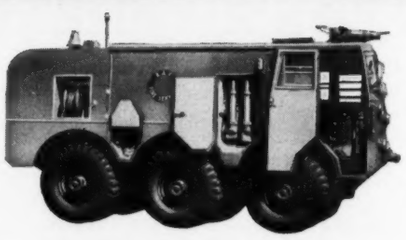

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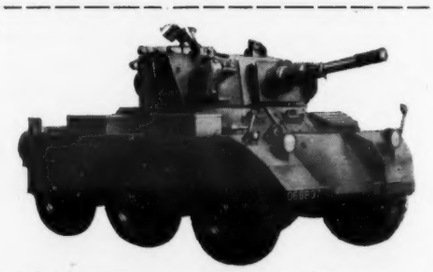

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Plastics in Rocketry

By Walter E. Field, Structural Materials Division, Aerojet-General Corporation, Azusa, USA.

In this era of missiles and spacecraft no single material can generally meet the exacting strength, weight, and temperature requirements of the aerospace designer. However, by properly blending the optimum properties of two or more materials, composites can be fabricated which meet specific requirements better than any of the individual components.

The idea of using composites is not new, for Greek mythology tells us that Icarus escaped from his prison in ancient Crete by flying over the walls with composite wings made of feathers and wax. What is novel is that our knowledge of materials and our refinements in fabrication techniques are being coordinated with specific application requirements, so that the composites we produce will keep our astronauts from falling into the sea as Icarus did when the sun melted the wax in his wings.

This type of coordination promotes successful application. Consider, for example, the rather simple problem of designing handles for frying pans, toasters, irons, and other similar appliances. The knowledge that mineral-filled phenolic resins can be easily molded to the desired configurations and that the cured composites are fire and heat resistant, structurally strong, and excellent heat insulators matches the performance requirements for appliance handles, and a successful application is achieved.

Of course, the aerospace designer is faced with a more complex task than the manufacturers of such domestic appliances, for he must evaluate many materials and properties and carefully match them to some extremely stringent application requirements, in order to assure the reliable performance demanded by the rocket and missile industry. Generally, however, his major problems involve heat resistance and weight reduction, and it is here that composite structures have achieved their greatest success.

Weight

In order to increase the performance of carrier-rockets and missiles, weight reduction must be accomplished without any decrease in load-carrying ability. This can be done by utilizing higher-strength, lighter-weight materials and, at the same time, by developing fabrication techniques which allow these materials to be directionally oriented during fabrication, so that the strength of the resulting composite coincides with the directional stress requirements of the structure.

The higher-strength, lighter-weight materials must, of course, be in a physical form which lend themselves to orientation; fortunately, such materials are available. The following table lists various materials used or considered for use in rocket motors. Relative strengths and weights are indicated by the tensile and density values shown. The ratios of tensile strength-to-density shown in the third column are a measure of the materials' load-carrying ability per unit of weight.

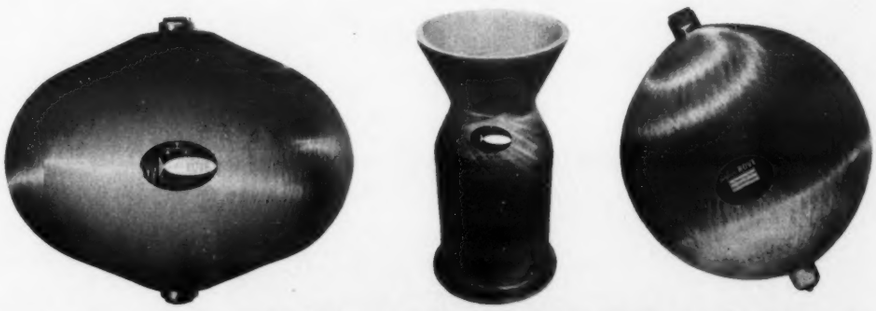
Material	Tensile Strength (psi)	Density (lb/cu. in.)	Tensile Strength/ Density Ratio ($\times 10^6$)
Aluminum Alloys	83,000	.100	0.83
Steel (6434 HT)	240,000	.283	0.85
Magnesium Alloys	55,000	.063	0.87
Steel Strip	300,000	.283	1.06
Titanium Alloys	180,000	.163	1.10
Steel Filament	550,000	.283	1.94
Glass Filament	270,000	.092	2.93

The last column shows at a glance, for example, that the lower density of titanium makes it a better choice for flying hardware applications than 6434 steel, despite the latter's high strength. The figures tabulated also illustrate the remarkable strengthening effect which occurs as the dimensions of a specific material are decreased, for a comparison of steel in the sheet, strip, and filament forms leaves no doubt as to the strength advantage of filaments. The values quoted also show clearly the outstanding strength-to-density advantages of glass filament, which can, moreover, be oriented and positioned in a composite.

To better appreciate the value of such orientation, let us see how glass filaments would help to reduce the weight of a cylindrical rocket case or fuel tank. Up to now, designers have generally made these components of metallic materials, such as steel or aluminium. These isotropic materials (so called because they have the same strength in all directions) are efficiently used in spherical vessels because the stresses acting in the walls of a sphere are the same in all directions.

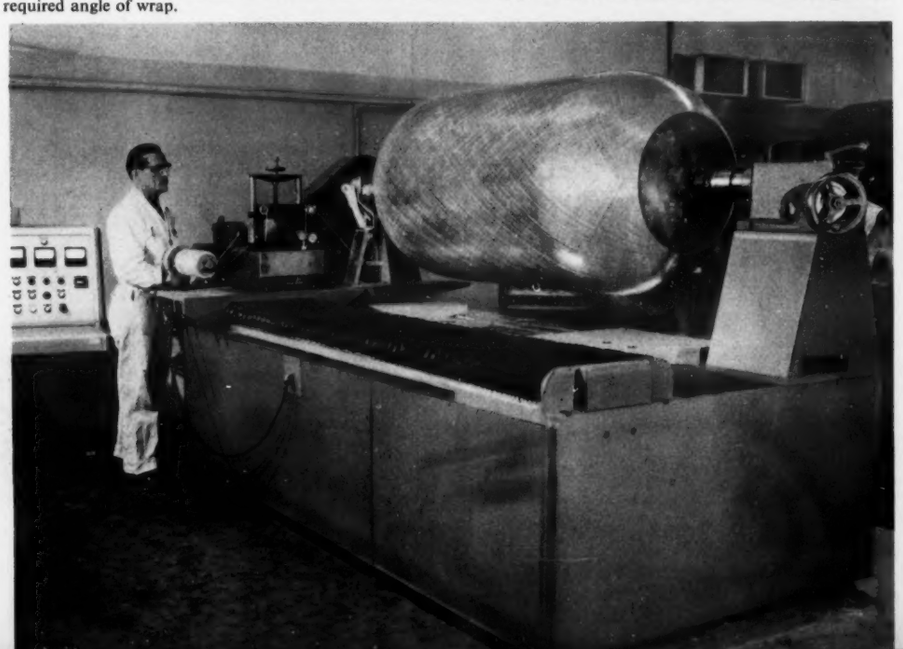
In pressurized cylindrical vessels, however, the hoop stress acting in the wall is twice the longitudinal stress and an isotropic wall made to withstand the hoop stress is overdesigned for the longitudinal load.

Directional orientation eliminates this redundancy, and reduces weight by efficiently positioning



Glass threads can be used to make hollow bodies of many shapes, the keynote being high strength coupled with light weight. Here are three examples taken from Aerojet General's production range. *Left:* an oblate spheroid pressure container. *Centre:* a rocket motor combustion chamber with thrust nozzle. *Right:* a spherical pressure vessel.

Cylindrical pressure vessels are made on this winding machine. The carriage (visible left in the photo) discharges the filaments as it travels from one end to the other. This motion is coupled with the rotation of the mandrel, to give the required angle of wrap.



Various sizes of filament-wound plastic igniter baskets, as used in solid-fuel rocket motors. The spiked object on the right is the original master from which plastic duplicates are prepared. Plastic moulds (top centre) made from the master tool serve in turn to form the spiked duplicates placed in the filament-winding machine.

the reinforcement in the composite wall so that its strength coincides with the 2-to-1 directional stress requirements of the cylinder. In spherical vessels, where stresses are the same in all directions, this advantage is however wasted.

One of the fabrication techniques developed to accomplish this type of orientation is called filament winding. As the name implies, it combines continuous glass filaments with selected resin systems to produce strong light-weight composite structures.

The filaments, as yarns or tapes, are wound around a core to form a reinforcing "cocoon." The selected resins permanently anchor the filaments in place and, in addition, help distribute the load between filaments and protect them from abrasion and other harmful environmental influences. Filament winding can be used to produce spheres, cylinders, cones, or other configurations that can be wound under tension. All in all this fabricating technique shows promise of producing units faster, more conveniently, and at a lower cost than by any other method now in use.

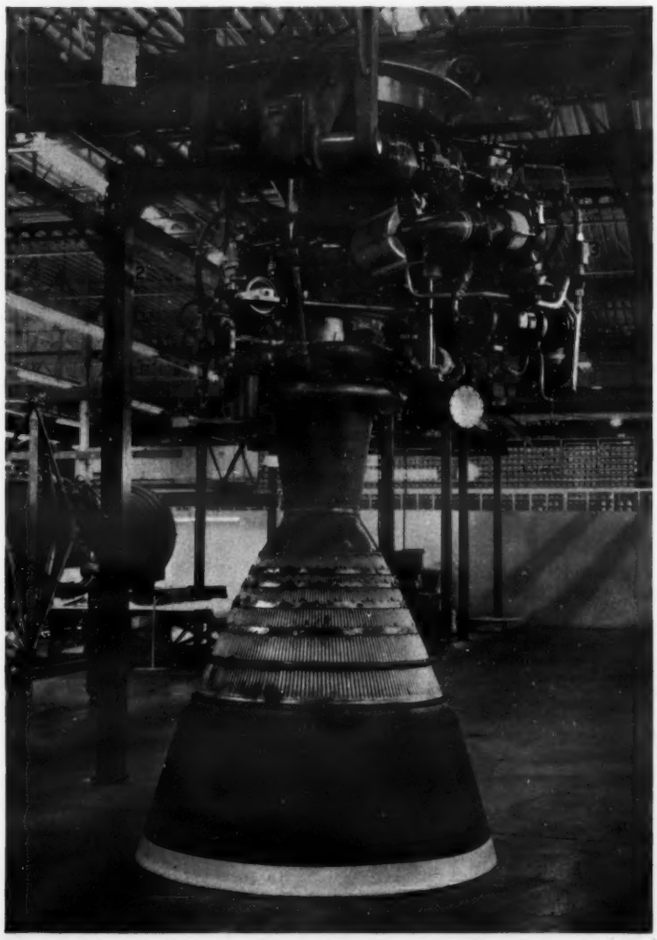
Examples of Applications

Igniter Baskets. One of the first applications for filament winding was its use with polyester resins to produce igniter baskets for solid rocket motors (see illustration left). These units spray fire on the solid propellant to ignite it, and need the continuous strength of filament reinforced structure to support the large number of "built-in" holes required for their function. Filament-wound baskets are moreover lighter, cheaper to produce, and more reliable than similar units made of wire or other materials which have been structurally weakened by drilling. Equipment has been designed for automatically winding these units with great accuracy. Individual cams control the winding patterns which can be programmed into this machine.

High Pressure Tankage. Filament winding is also used to fabricate containers for pressurized gases and liquids. Containers made by this method have gained enthusiastic acceptance for the storage of air, helium, nitrogen, nitric oxide, and many other materials. They withstand continuously variable internal pressures and at the same time provide weight savings, corrosion resistance, and resistance to shattering not available in equivalent metal units. Filament wound spheres have been designed and fabricated to meet burst pressure requirements as high as 20,000 p.s.i. and to operate in the −65°F to +200°F temperature range.

Early development work in this field was almost entirely restricted to spherical containers, but now that the difficulties have been overcome and the value of these units has been demonstrated, other shapes, such as cylinders and oblate spheroids are being designed and fabricated.

These shapes take greater advantage of the directional orientation made possible by filament winding, and automatic machines are being fabricated which will extend these advantages to rocket cases as well as to many other rocket and missile applications.

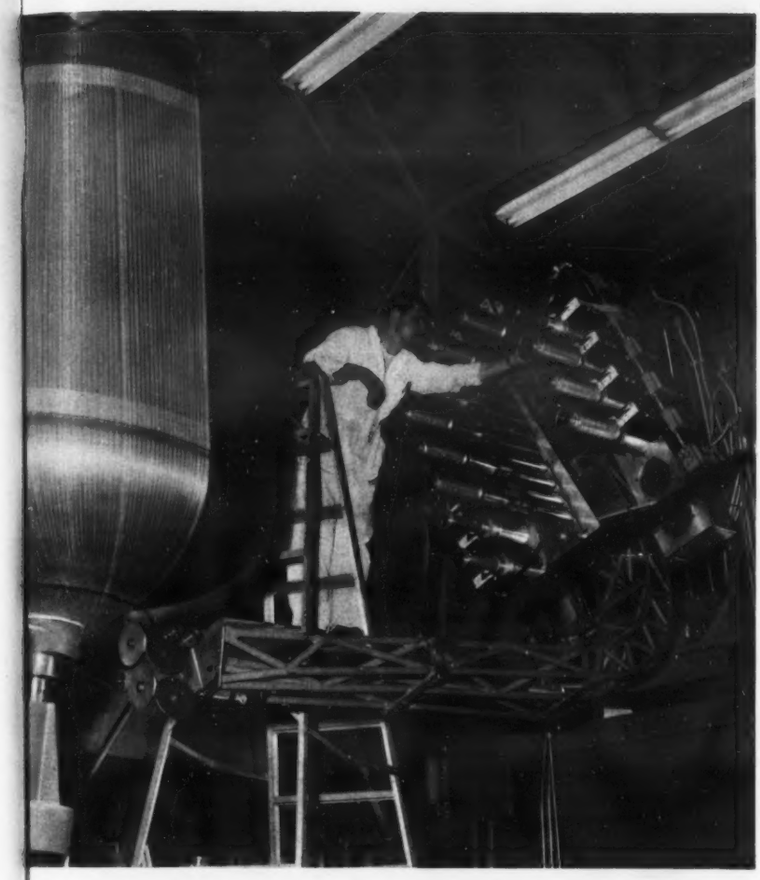


An ablative blast-protection layer used instead of wall cooling. *Above:* The exhaust nozzle of a solid-fuel motor; graphite and other refractory coatings protect the areas subject to erosion. *Below:* The thrust chamber of a liquidfuel rocket motor. The inner coating consists of spiral-wound resin-impregnated insulating tapes with high-temperature ablation characteristics; after curing, they are densely wrapped with glass filaments.

For the second-stage motor of the Martin *Titan* intercontinental rocket, Aerojet has developed an expansion nozzle, whose outer portion is clad with an ablative heat shield (dark area). Blast-effect protection is provided by an asbestos-reinforced phenolic liner. The necessary strength and stiffness are imparted by a glass-fibre reinforced phenolic honeycomb.

Thermal Composites

Oriented materials are also helping the aerospace designer to solve some of his high temperature insulation problems. In this application, however, the materials, Refrasil and asbestos tapes, impregnated with high temperature resins, are positioned for optimum thermal properties. This eliminates the interlaminar stress and peeling action common to conventional composites, allowing decomposition gases to escape easily



This type of thrust chamber is proposed by Aerojet-General for the second stage of the *Polaris A-3*. The glass filament winding machine, visible on the right, in Aerojet's Azusa plant is believed to be the largest of its kind in the USA. It can handle units up to 30 ft long and 14 ft in diameter.

without destroying the structural integrity of the laminate. The cured composite also has substantially greater heat capacity and thermal conductivity properties than non-oriented laminates and, most important of all, provides an ablative surface which erodes uniformly. Tests have shown that, even after 4 minutes exposure to exhaust gas temperatures in excess of 6,000 °F, these surfaces are essentially smooth and free from blisters and excessive pitting.

Thrust Chambers

Ablative construction is now replacing the heavy, complicated, and expensive "plumbing" formerly required for the cooling of liquid rocket thrust chambers. The ablative liner in these uncooled plastic units is made by winding the resin-impregnated insulating tapes around a removable mandrel. After curing, the outer diameter is machined and completely overwrapped with glass filaments to provide the required structural strength.

Exit Cones

If erosion conditions are particularly severe, the throat area can be made of graphite or another refractory material. This combination achieves significant weight savings, greater resistance to thermal shock, and better over-all performance. Where deflection or vibration are critical factors, the composite can be stiffened with a honeycomb core, which may be sandwiched between the ablative liner and the outside reinforced plastic skin.

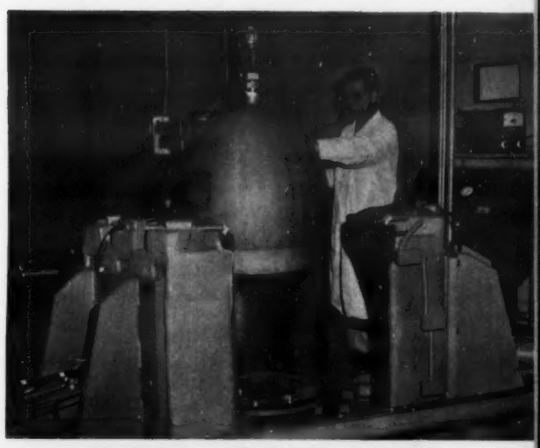
Nose Cones and Fairings

Ablative composites are also used in the fabrication of nose cones and fairings. In space probes for example, the payload must be protected from extreme heat and abrasion whilst passing through the earth's atmosphere. Nose fairings, made of two equal half sections held together with explosive bolts, accomplish this. Once the payload clears the atmosphere, an electrical impulse to the bolts allows the fairings to separate and expose the payload.

Missile Warheads

Light weight composites of glass reinforced plastic are also used in the manufacture of warheads for missiles. Depending upon design and mission, units are in some cases made of polyester resin with pre-mixed chopped glass. This material can be easily molded, and the individual parts adhesively bonded to form the finished unit.

Other larger units are completely created by hand lay-up and subsequent molding in specially-built presses. Plastic-reinforced composites have produced end items which are stronger, more reliable, and less expensive than their counterparts made of other materials.



A *Nike-Hercules* warhead housing going into the curing oven. These warheads use a large amount of polyester resin, which is reinforced with glass choppings.

Full-scale mock-up of the Aerojet *Able* carrier rocket second stage, with plastic nose covering.

The Future

...And the search for new materials and new fabrication methods continues. Man will soon be making long space flights and, with this change in his environment, the search for new concepts and new ideas to be developed will be more important than ever. As an example, many delicate items are now potted or packaged in plastic foams to protect them from damage. These materials work well while there is air pressure but, in the airless hold of a spaceship, they may expand and blow up from their own internal pressure. Sealants which efficiently perform their function on earth, may have to be modified to withstand the constant vacuum of space. These, and many other similar problems, offer the challenge for the future—but they will be solved, for man has his eyes on the stars. ←←

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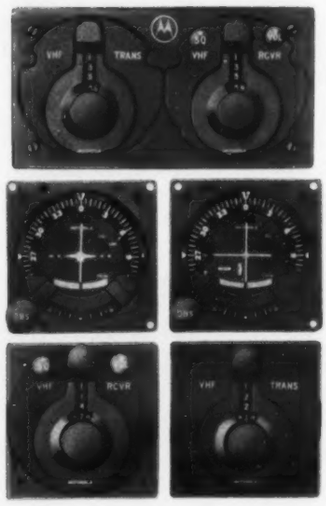
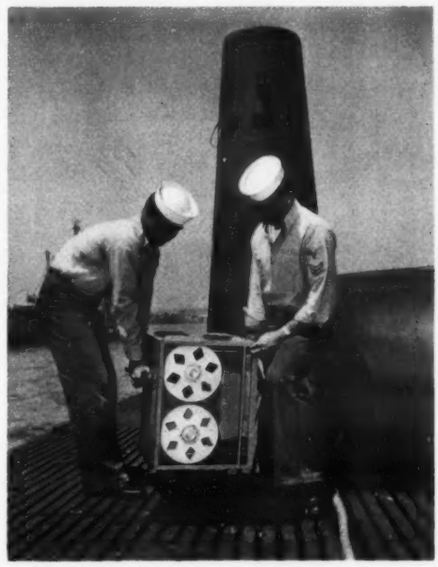
Research and Production News

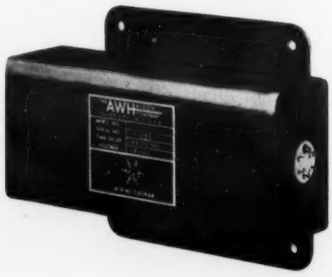


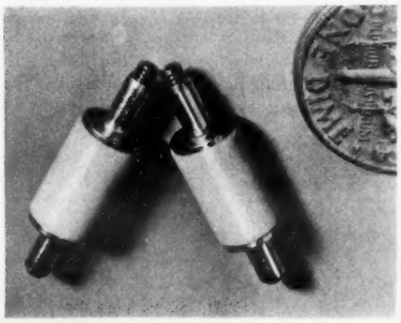
• **Motorola Aviation Electronics Inc., Culver City, Calif.,** a subsidiary of Motorola Inc., has put a new VHF radio and navigational equipment for executive and touring aircraft on the market. Including the marker-indicator (supplied on request) which consists of three lamps, the whole equipment weighs only 22 lb. It consists of a transmitter (8W power), receiver, power supply, glide slope receiver, VOR/LOC- and VOR/ILS-indicator. The standard design of transmitter has 90 channels (118-126.9 Mc/s). The receiver has 190 channels (108-126.9 Mc/s) spaced at 100 Kc/s. If desired, a further model of the same type can be supplied with a larger number of channels (360/560 channels, 118/108-135.95 Mc/s) spaced at 50 Kc/s. In addition to this, a further frequency outside the ranges mentioned can be utilized by means of a plug-in quartz crystal.

Our illustration shows the one-box receiver/transmitter control unit (top), the VOR/LOC indicator (left centre), VOR/ILS indicator (right centre), and receiver and control units in separate boxes (bottom).



• **The A. W. Haydon Company, Culver City, Calif.,** has produced an extremely accurate electronic timer ("Series 31800"), which has a time delay range between 50 milliseconds and infinity. Operational accuracy is 0.01 percent. The timer works reliably at all temperatures between—54°C and +71°C and at altitudes of up to 50,000 feet. It resists shocks up to 30 g and vibrations of up to 500 c.p.s. at 10 g. At 28-volt a.c. or 115-volt d.c., the contact rating is 10 amps.





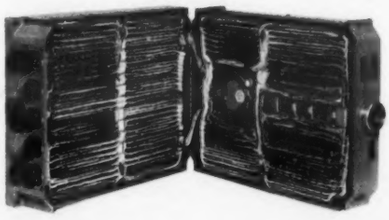
• **Raytheon Company, Waltham, Mass.,** is offering a new variable-reactance semiconductor diode. The gallium arsenide varactor serves for low-noise microwave amplification. For example, the effective range of radar equipment can be boosted by up to 50 percent through the use of the varactor.

• **Consolidated Electrodynamics Corporation, Pasadena, California,** a subsidiary of Bell and Howell, have developed the PR-2300 tape-recording and reproducing apparatus which is of relatively light weight, and whose efficiency is equal to that attained up to now only by significantly larger equipments. The pick-up/playback apparatus weighs 150 lb and measures 18 in × 14 in × 23 in. Fourteen channels are available for playback or for broadband FM analogue data. The tape speed can be changed in six steps (60, 30, 15, 7½, 3¾, 1⅞ in per sec) by changing two driving belts. Memorized information can be played back in both directions. The pickup and playback amplifiers are separately housed in an additional cabinet measuring 18 in × 14 in × 3½ in and weighing about 24 lb. The tape-recorder is robustly designed and operates within a temperature range of 4.5°C to 68°C with the utmost reliability. A power supply of 115 V 60 c/s is required.

• **The Solartron Electronic Group Ltd., Farnborough** has developed a new radar simulator, which is characterized by its small dimensions as well as by its very high reliability and precision. The apparatus is fully transistorized and requires no more space than an ordinary office desk. Six synthetic radar targets can be simultaneously displayed and, in order to obtain the most realistic production possible for the training of radar air-traffic controllers, the simulator has been provided with special characteristics including: variable size of echo (dependent on distance of target); insertion of artificially produced echoes from meteorological disturbances; MTI; adjacent echo attenuation; circular polarization; video-map; variable wind-strength and direction at various layer heights.

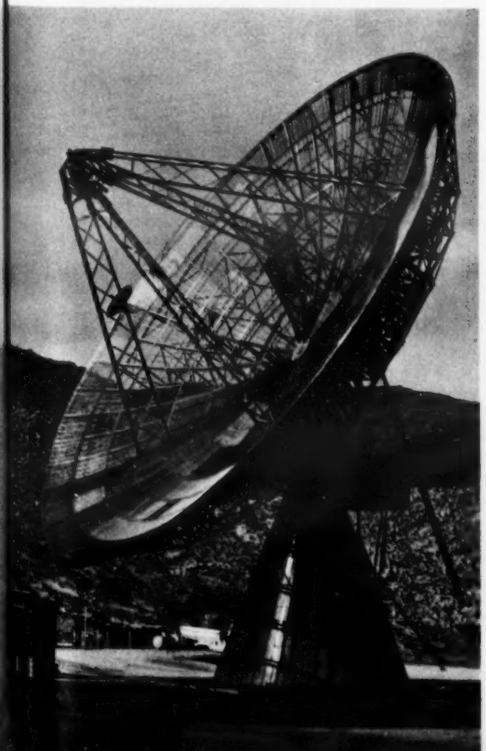
Being fully transistorized, this new radar simulator requires no special cooling arrangements. It makes extensive use of printed circuits, which include a number of Solartron's standardized printed-circuit boards. These are colour-coded according to their different functions and can be changed by hand.

• **Autonetics, a Division of North American Aviation Inc.,** included in its Paris Show exhibit the VERDAN miniature Digital Computer, produced under licence in Great Britain by Elliott Brothers (London) Ltd. The computer measures only 15¾ in × 8 in × 19⁹/₁₆ in. Its design makes considerable use of semi-conductors and plug-in modules, which make for a high degree of reliability and great sturdiness. The computer is the core of the inertial navigation system of the air-to-ground GAM-77 *Hound Dog* missile, where it fulfils two functions: on the ground, it serves for the testing and calibration of the missile guidance system (at the same time it is self-checking). As soon as this test programme has been concluded, the flight programme is fed into the computer and kept with the calibration factors already stored. After the missile has been launched, the VERDAN computer ensures that it reaches its target, so that the *Hound Dog* can even make a mock attack, turn suddenly from the supposed target, and then fly to its real target. The VERDAN Digital Computer can be utilized for the inertial navigator of the *Polaris* submarines as well as for the navigation and guidance systems of the North American A3J *Vigilante*. Autonetics is at the moment reported to be working on further miniaturization of the VERDAN coupled with an increase in capacity.



• **Marconi's Wireless Telegraph Co. Ltd., Chelmsford,** has announced that it will exhibit several new and interesting items of equipment at the forthcoming Farnborough Show. Among them is a tabular display unit, which can be used as a component of a data-processing system—such as an automatic air-traffic control system. On the SD 1016 rectangular cathode ray tube, which is 7 in wide and 5 in high, 400 alpha-numerical symbols can easily be seen at a distance of 2-3 ft. even in daylight (illustration below). The control unit of the equipment can produce 50,000 characters per second. In a time-multiplex process, 10 such screens each display 250 characters simultaneously and independently in what is described as a typical application. The individual numbers or letters may be corrected without affecting the remainder of the display.

Another recent Marconi development is the Radar Display Console SD 1015, which permits "raw" radar signals and synthetically-produced information to be displayed simultaneously. The latter can, for example, be derived from the buffer memory of an electronic computer, and can include radar-echoes, alpha-numerical characters and symbols etc. The upper diagram shows a layout of the new Marconi equipment: *extreme right*—the cathode ray screen SD 1015; *left* (*in shadow*)—the cathode ray screen SD 1016 for tabular display. The television screen on the extreme left is used for displaying meteorological information.

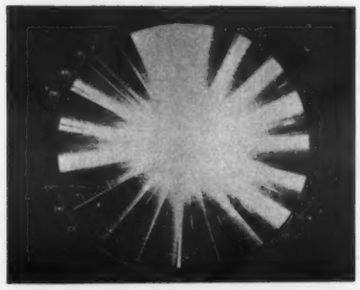


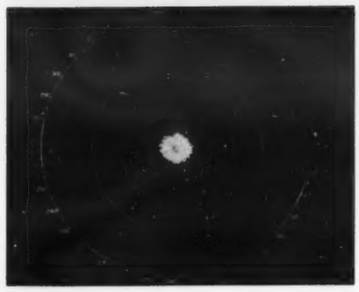
• **Varian Associates, Palo Alto, Calif.,** have developed an extremely powerful microwave amplifier system which made an important contribution towards the success of experiments carried out some time ago, in the course of which radio signals reflected from Venus were received. Heart of this amplifier system is the VA-800C klystron, which has a power-output of 10 kW at a frequency of more than 2000 Mc/s. In order to eliminate troublesome moving joints between the antenna and power supply, the klystron and its components are built inside the framework of the reflector (see illustration), which was set up in the Mohave Desert, California. The experiments commissioned by NASA and carried out by scientists of the Jet Propulsion Laboratory were successful in so far as the radio signals reflected from Venus were received so clearly that no elaborate and tedious analysis was required. A few months ago, the same equipment served for the transmission of radio signals between California and Australia, using the moon as reflector.

• **Avco Corp., Electronics and Ordnance Division, Cincinnati, Ohio** has recently delivered the first two of a set of equipments for the AN/FPS-26 high-powered height-finding radar equipment to the US Air Force. The FPS-26 will be used in conjunction with the US Air Force long-range search radars around the North American Continent for the monitoring of aircraft.

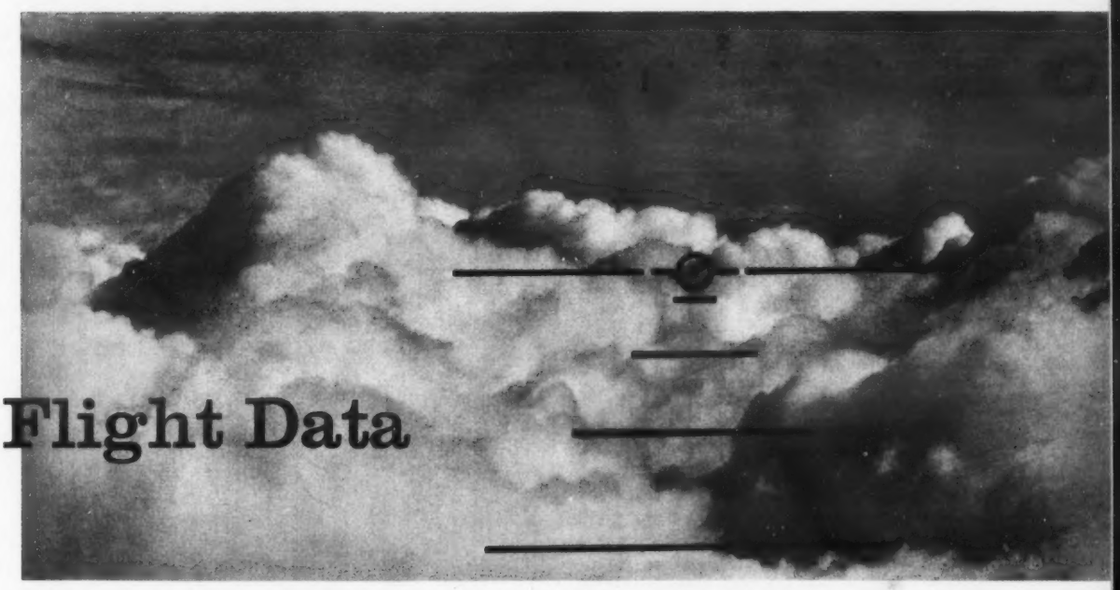
• **Maschinenfabrik Augsburg-Nürnberg (MAN), Gustavsburg,** has set up a new radio-telescope near Parkes, NSW (about 200 miles from Sydney, Australia). This telescope will be used by the Commonwealth Scientific and Industrial Research Organization, Melbourne, for radio-astronomical research. The telescope has a reflector with a diameter of 21 ft, covered with an 8-mm steel wire mesh. The illustration shows a 1:50 scale model of this radio-telescope.

• **Ling-Temco Electronics Inc., Dallas, Texas** has developed the "Video Correlator," which can be built into any radar set to offset interference from radar transmitters operating in the vicinity, which is often quite considerable. The concern has already fitted a large number of radar sets of the US Air Force, Army, Navy and Marine Corps with the video correlator. In the manufacturer's opinion, it is cheaper to equip an existing radar set with the device than to buy a new one proof against disturbances of this kind. Illustrated are (above) a cathode ray display with heavy interference from a nearby radar station, and (below) the identical display using the video correlator.





• **Standard Telephones and Cables Ltd. (STC), London,** is carrying out tests at London Airport aimed at the integration of the PVT.2 automatic triangulation direction finding system (see *Interavia* No. 8/1961 page 1126) with the standard air traffic control surveillance radar. The test installation (illustration) includes a radar console, the PVT. 2 system's television screen, and a control unit operated by a "joystick." As soon as a pilot depresses his microphone button, two or more CADF stations automatically take a bearing on this signal (VHF or UHF). The bearings thus obtained are presented as white lines on the television screen, the point of intersection denoting the aircraft's position. By means of the "joystick", an electronically-generated symbol (such as a dot, circle, or square) can be moved across the screen to mark the fix. The symbol also appears on the radar scope at the same geographical point and thereby indicates the location of the aircraft whose bearings were taken. In this way, a radar contact can be identified much more quickly and easily than by the usual methods employed; this greatly facilitates terminal-area radar control, especially under heavy traffic conditions. It is understood that tests of this new system being carried out by the Royal Navy and the Royal Air Force are proceeding satisfactorily. The equipment is available within a relatively short delivery time, and the radar consoles in use require only minor modifications to enable them to reproduce the identification symbol.



PEEP
Eye-level Flight Data

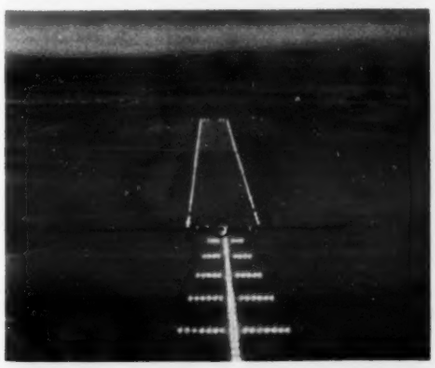
The pilot of a modern aircraft must constantly divide his attention between the instrument panel and the "outside world." During visual flight conditions, he must maintain a continual watch for other aircraft to ensure sighting them in ample time, and simultaneously monitor with vigilance the numerous instruments, impressively arrayed in a modern aircraft, for navigation, flight attitude, and engine performance data. Under instrument flight conditions, the problem is even more acute. The pilot is completely dependent on his blind flying instruments for the indication of the safe flight path—down to the obstacle clearance limit. If, at this point, he cannot see the ground owing to poor visibility, he must break off the landing procedure and start again. Technical advances notwithstanding, the pilot is still obliged to carry out the terminal landing and touchdown procedures visually. In many cases, the timely recognition of landing lights glimmering through fog or snow is a prerequisite for a safe landing. The pilot's attention is thus always divided between the instruments and the flight path ahead. The frequent re-focusing of the eyes from infinity down to the instrument panel, and the contrast between the inner and outer illumination levels, result in considerable eyestrain and fatigue. Moreover, when this "split-attention" condition is protracted, a dangerous situation arises—one which has already been responsible for a large number of accidents.

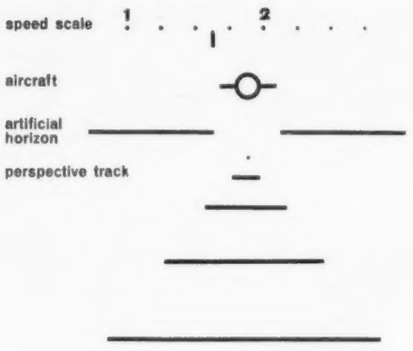
In order to remedy this problem, Rank Cintel Limited (London) has developed, on behalf of the British Air Ministry, a device for the display of the more important flight and navigation data. Based on the principle that the best place to display such information is directly in the pilot's line of sight, this firm has produced the PEEP (Pilot's Electronic Eyelevel Presentation) system, which is now also offered for civil use. Electronically generated symbols are so displayed as to give the pilot the impression that the pattern is projected onto the ground or clouds ahead. The pilot need neither move his head nor refocus his eyes in order to perceive the data presented to him by this projection system. The PEEP pattern appears to be focussed at infinity.

The complete PEEP equipment includes the Pilot's Display Unit, Waveform Generator (to supply the cathode ray tube deflector coils), and the Coupler (data transformer). The complete set weighs only 50 lb and the power consumption is 75 watts. The Coupler first converts the data from the airborne instruments into a form suitable for feeding to the Waveform Gener-

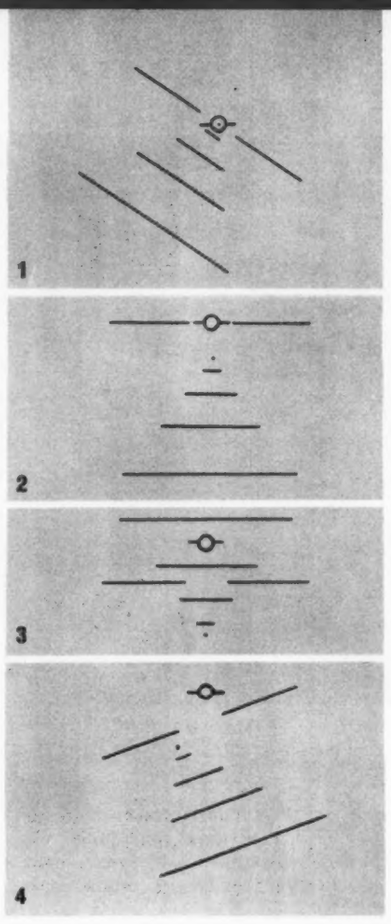
The heart of the PEEP system is a high-performance cathode ray tube which is built into the Pilot's Display Unit, together with its electronic circuitry. A lens assembly projects the pattern generated on the screen directly onto the aircraft's windscreen or onto an oblique reflecting screen. In either case, the image pattern is displayed at the pilot's eye-level.

The PEEP system is easily adaptable to a variety of needs and to many air-borne equipments. The simplest version uses only an aircraft and horizon symbol in its pattern (see illustrations below). The standard model includes also a perspective track symbol, resembling a runway approach (illustration at upper right). Correct course and altitude are maintained when the aircraft symbol is kept centered on the director-dot. Depending on the equipment on board, data from the following instruments can be displayed: reference gyro (flight attitude), compass (heading deviations), flight data computer and altimeter (altitude variations), airspeed indicator (display of air speed on scale), ILS (lateral and vertical deviations from landing path). The lower illustrations show examples of the simplified indications. *Left:* normal flight attitude, on course. *Centre:* correct course, aircraft banking to the right. *Right:* too high, off course to the right, banking to the left.





ator. The latter provides the deflector coil voltages which generate the proper symbols displayed on the face of the cathode ray tube. By means of a system of lenses and a mirror, these symbols are projected directly onto the windscreen of the aircraft, or if its configuration does not permit this, onto a glass reflector on the display unit (see illustration). The display of information is fully automatic and continuous, and the maximum luminosity of the projected pattern (green by day, and orange at night through the use of a filter) makes it clearly visible even against bright clouds. The pilot only has to select the desired brightness of the projection display; he has no other adjustments to make. An automatic regulator maintains the contrast between the pattern brightness and the ambient lighting at a constant level.



Examples of standard PEEP display; 1 - left bank; 2 - horizontal flight, too high; 3 - descending, too low; 4 - right bank, climbing, too high, off course to the right.

The normal PEEP indications provide the pilot with all the information needed to monitor flight attitude, heading, altitude, and speed. Additional data can also be incorporated in the display if desired, such as a scale showing the distance flown, the height above terrain for ILS landings, and so on. The current version of the PEEP display unit shows all information within a 25° sight angle. However, a wide-angle display can also be provided by suitable modifications in the lens system. Experienced pilots, who have tested the PEEP system in use, are impressed by the clarity and inherent simplicity of the display. After an average of four minutes of test flying, they were able to control the aircraft guided only by the projected pattern—and to do so with a much higher degree of precision than with the normal instruments. Tests have shown that the use of the PEEP system enables the pilot to perceive a distant object, e. g. an aircraft on a convergent course, an average of three seconds sooner —precious, perhaps critical, seconds, given the speeds of modern aircraft. ←→

RACEP - A new radio telephone system

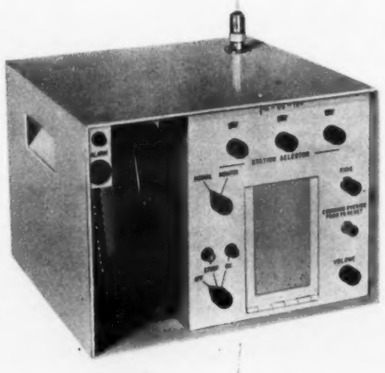
The Martin Company has brought out a new mobile radio communications system, called RACEP (Random Access and Correlation for Extended Performance). Working in the same way as an ordinary telephone system—but without the use of wires or central switchboards—RACEP enables any subscriber to contact any other subscriber. Conference calls and other special patterns are likewise possible, and the command override feature allows all subscribers to be called simultaneously from a single transmitter for high-priority messages.

The RACEP system is based on a completely new modulation technique, and makes full use of the idle time between individual calls and of the short, but frequent, pauses and breaks in normal conversation. The RACEP equipment so far built by Martin permits uninterrupted simultaneous communication on 70 channels (35 duplex channels). Martin engineers assume that, owing to idle time between calls and pauses in speech, only about 10 percent of the overall time is actually required for transmission, so that the current design affords a ten-fold increase in capacity. Thus RACEP can handle 700 subscribers, using a single channel of only 4 Mc/s bandwidth in the VHF or UHF range, which represents a marked economy in frequency spectrum requirements over present-day radio communication systems.

Simultaneous speech by several subscribers on the same frequencies is made possible by the use of Pulse Position Modulation (PPM). The speech waveform is first converted to a form of pulse position modulation, which is then broken down into individual sub-pulses. Each sub-pulse is transmitted on a separate carrier-frequency in the 4 Mc/s bandwidth after the insertion of time-delays corresponding to the address-code of the subscriber being called. While the latter's receiver may be within range of the impulses sent out by all the transmitters in the network, it selects only those sub-pulses with the appropriate time-delays. The sub-pulses in a pulse-group are reconstituted into the original PPM pulses, which are then converted back into speech waves.

The use of extremely short pulse durations (about one microsecond) reduces cross-talk to a minimum during simultaneous conversations. In the event, however, of the number of simultaneous conversations or the system load factor temporarily exceeding a certain level, increasing static background noise makes itself heard, and the subscriber will react by taking the trouble to speak more distinctly, and with more pauses, thus reducing the load factor. Besides, argues Martin, he may also postpone less important conversations until a more favourable time, when the system is less heavily loaded.

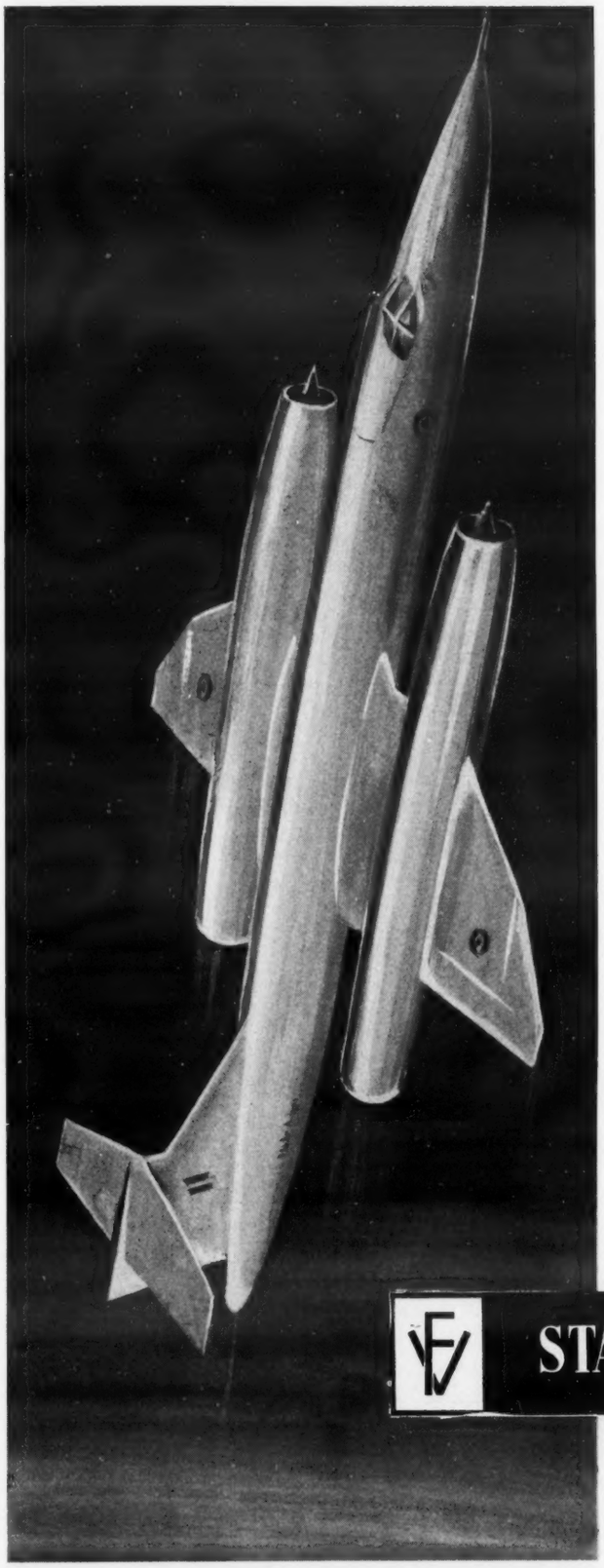
Martin developed RACEP on its own initiative and with its own resources, as the firm takes an optimistic view of the system's prospects for wide use and further development, for it has many fields of application and numerous advantages. RACEP can, for example, be used in air-ground voice communications for air traffic control. Instead of all the frequencies required by current military and civil ATC systems falling in a 26 Mc/s waveband, all traffic increases expected as far as 1970 could be served with two frequencies of 4 Mc/s bandwidth—a reduction of about 70 percent, which, in view of today's already overloaded frequency spectrum and lack of radio communication channels, represents a very worthwhile improvement. Since RACEP can transmit both voice and digital data, it can be used for fully automatic air traffic control and data transmission using only one 4 Mc/s frequency bandwidth, thus giving a further 50 percent economy. Moreover, a single transmitter and receiver may serve as many subscribers as desired at one airport, instead of the numerous frequencies and many individual transmitters and receivers required today to fulfil the same purpose.



In military applications, one of its most important features is that the encoding of the transmitted information is inherent in the RACEP principle. The conversion of speech into PPM pulses and their breakdown into time-delayed sub-pulses ("time-frequency matrix") amounts to a double encoding, which prevents listening-in by anyone other than the addressee. Also, the system's ability to transmit a large volume of both voice communications and data simultaneously, should enable it to be used with advantage in, for example, simultaneous firing of numerous guided missiles, since only a single frequency would be required to transmit the necessary control commands to all the missiles in question.

Furthermore, the RACEP equipment requires very little modification to give it transponder capability. When so used, great distances can be linked by radio economically and without the need for complex installations. A RACEP type relay station, if installed in a communications satellite, would provide world-wide voice communications and data transmission service.

The Martin Company has supplied six RACEP units to the US Air Force for testing purposes; they weigh less than 35 lb each, and their dimensions are 14 in × 14 in × 12 in. Power is supplied by a 24 or 30 volt battery, and power consumption does not exceed 200 watts. The range of these models is about 15 miles, but substantially increased range and capacity are within the possibilities of the system. ←→



STILL PIONEERING

The continuous research and development of special Stainless, Heat and Creep-Resisting Steels carried out by Firth-Vickers since the early days of aviation has made possible the continual improvement in performance and efficiency both of airframes and engines.

This experience proved invaluable during the close co-operation between Firth-Vickers and Bristol Aircraft Limited when steels and methods of fabrication for the construction of the T.188 Supersonic Research Aircraft were considered.

Plate, Sheet, Bar and Forgings produced by Firth-Vickers account for over 90% of the Stainless Steel used in the construction of this aircraft.

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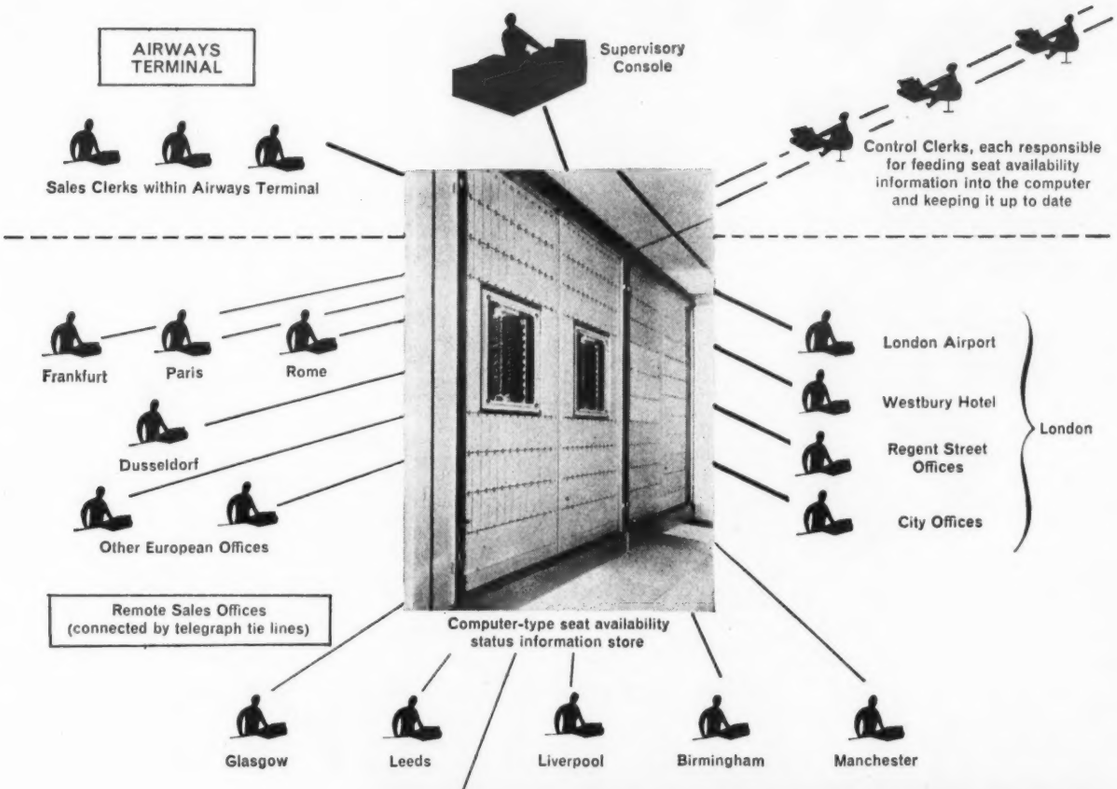
Fifth engine tests Boeing 727 design feature

The Boeing 707 prototype, which proved out advanced design features of the Boeing 707 and 720 jetliners, is now at work as a flying test bed for the next generation of Boeing jets — the three-engine short-range 727.

The prototype is shown above equipped with a fifth engine, conducting exhaustive tests of the efficiency and performance of side-mounted engines, a feature of the 727. In addition, the 707 prototype is testing new high-lift wing flaps, aircraft systems and other design features that will make the 727 the most advanced jetliner of its class.

Already, ninety-two 727s have been ordered by Eastern Air Lines, Lufthansa German Airlines and United Air Lines for delivery beginning in 1963. The 727 will operate from 5,000-foot runways with full payload and will serve routes from 150 to 1700 miles. It offers airlines many unique advantages, including components and systems that have demonstrated outstanding performance and reliability in more than 300,000,000 miles of Boeing jetliner operations.

BOEING



STC electronic reservation system for *B.O.A.C.*

Unceasing expansion of B.O.A.C's passenger traffic created a need for a fast and dependable seat reservation method. A new electronic system, developed and manufactured by STC, will enable B.O.A.C. offices in the U.K. and throughout Europe to obtain immediate access to information on seat availability.

The central equipment will be installed in the Terminal Building in London and will be capable of answering 8,000 queries a minute. About 200 Sales Personnel will have remote access to this central processer equipment which uses computer type magnetic drums for information storage.

STC Seat Reservation Systems are designed to utilize established national and international communication networks. The systems operate at high transmission speeds and incorporate error-checking facilities.

Visit the STC Stands 156-159 at the Farnborough Air Show.

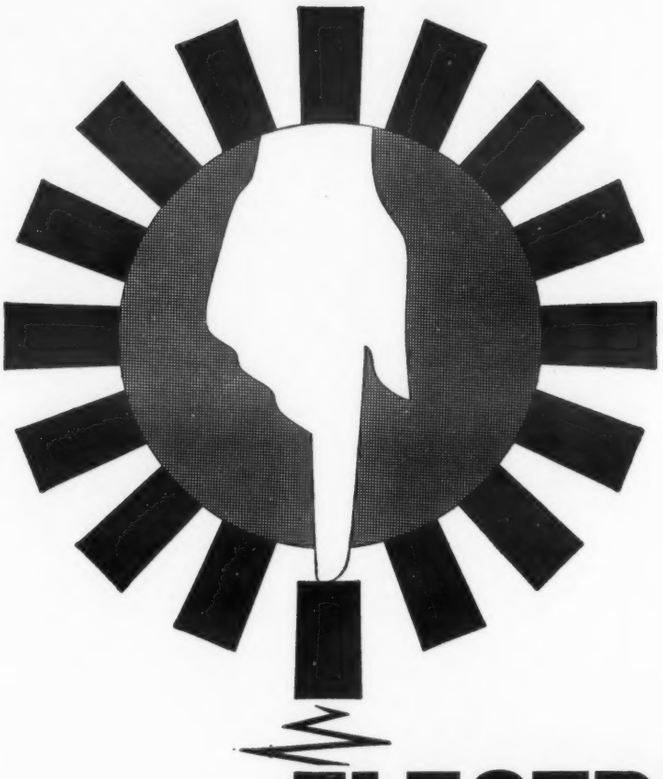
Technical details are given in brochure available on request from:—

STC INDUSTRIAL ELECTRONICS GROUP

61/3L

Standard Telephones and Cables Limited

INFORMATION PROCESSING DIVISION: COPORATION ROAD · NEWPORT · MON



ELECTRONIC COMPUTER EXHIBITION

AND THE ELECTRONIC DATA PROCESSING SYMPOSIUM

NATIONAL HALL OLYMPIA London

OCTOBER 3rd-12th 10·30 am to 7 pm

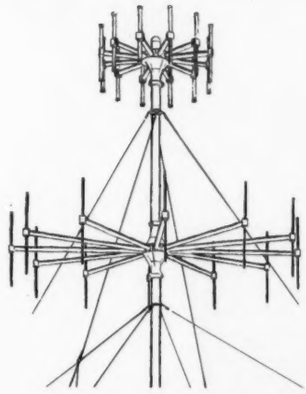
October 3rd only NOON - 7 pm Sat. 10·30 am to 4 pm

Visitors to Olympia can see a working demonstration of some of the most up-to-date electronic computers and ancillary equipment in the world. Britain's leading manufacturers will display their latest equipment, and experts on the various stands will be ready to offer information and advice about electronic data-processing of every sort. Whatever the size and nature of *your* business, here is an exhibition you cannot afford to miss. If you cannot attend yourself, you should at least send an observer.

THE ELECTRONIC DATA PROCESSING SYMPOSIUM

During the Exhibition a three day symposium will be held. Executives, well versed in computer techniques, will come from a wide range of concerns—both State and private enterprises—to give registered delegates the benefit of their user knowledge and experience. All six sessions will be informal, and a highly useful exchange of ideas and information will result.
For further information contact Mrs. S. S. Elliott, M.B.E., 64 Cannon Street, London, E.C.4. Telephone: CENtral 7771/2.

SEE THE NEW GENERATION OF COMPUTERS AT WORK



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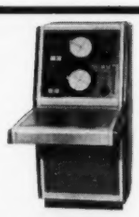

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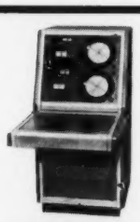

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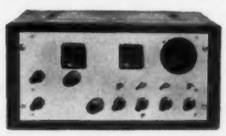

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The AN/GSN-11 Automated Terminal Air Traffic Control System

by F.C. Shadley and R. Meuleman, Avco Corporation, Cincinnati, Ohio.

To satisfy the constantly increasing demands on ATC, the use of automatic aids is indispensable. The industry and the authorities have for some time been actively concerned with the development of satisfactory systems and procedures. Congestion of the ATC system is becoming more and more critical and it seems essential, once the available systems have been carefully tested, to reach a decision as soon as possible. To assist the reader in forming a picture of the general situation, Interavia *regularly reports on all new proposals, even when no practical investigation results are available. The following contribution, by two of the staff of AVCO Corporation, deals with a terminal area control system at present being tested by the FAA.* The Editors.

The toughest challenge in air traffic control is the terminal area, a radius of 60 to 90 miles surrounding every high density airport. The US Air Force, having been faced with the need for efficient handling of jet and propeller traffic in their return-to-base operations, has over the past three years sponsored the development of an advanced terminal area control system. The techniques utilized in this system are worthy of careful consideration in solving the general terminal area traffic control problem.

Based on sophisticated arrival scheduling, a gradually tightening computer-pilot-radar control loop, and a technique for automatic ground-air voice communications, the system is scheduled to begin flight testing at FAA's Atlantic City test center this coming summer. Designated the AN/GSN-11 Air Traffic Control Central, the six-console, 50-cabinet system was developed by the Electronics and Ordnance Division of AVCO, Cincinnati, Ohio.

To achieve the high precision necessary for maintaining safe positive separation while still increasing traffic rate to the theoretical maximum, a closed loop vectoring system is necessary. The rate at which aircraft can be landed at an airport is dependent on the precision with which arrival times can be controlled. In manual radar approach control, an aircraft can be vectored to arrive at touchdown within ± 30 seconds of the desired instant. Among the many factors preventing a tighter delivery precision are wind drift, communications delays, pilot and aircraft reaction time, heading and speed errors. Even so, the precision achieved by manual radar delivery is far superior to that possible with the "timed approach" utilized previously, and still resorted to during radar shut-downs. Critical to the achievement of higher acceptance rates is the problem of common-path overtaking. When a fast aircraft follows a slow one, enough additional separation must be allowed so that, when the fast aircraft comes onto final approach, it does not violate safe separation from the slower aircraft preceding it.

System Description

The AN/GSN-11 (*Fig. 1*) is a ground-based electronic traffic control system capable of simultaneously controlling 18 arriving aircraft (in batches of six, assigned to three console operators) and six departures in a terminal area. Each arriving aircraft is assigned an individual tracking-computing channel, which schedules a precise touchdown time and closely controls the aircraft to ensure adherence to the schedule. Automatic approach-control instructions computed by the AN/GSN-11 are dependent on the continuously moving position of the aircraft, determined by a surveillance radar.

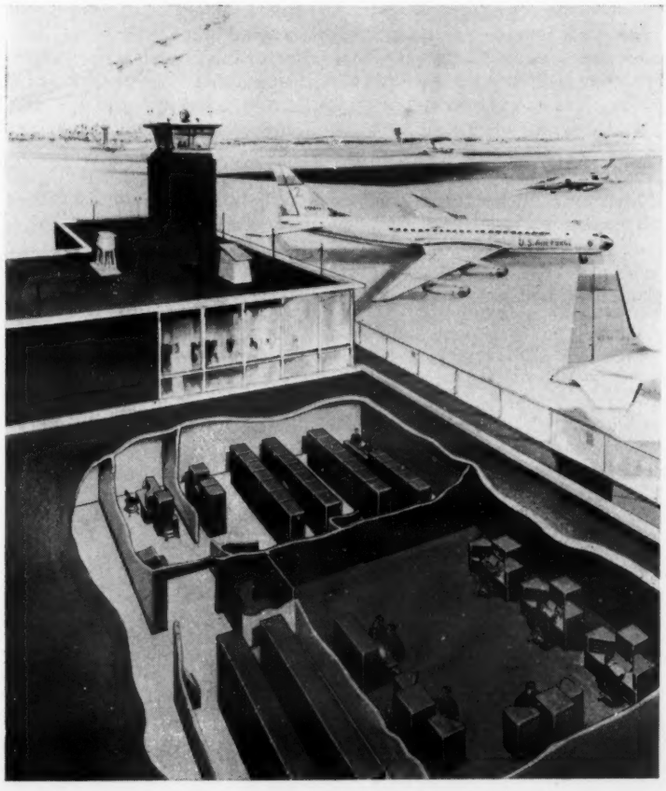
This typical installation is divided into two parts—the operations or control room, and the equipment room. Installed in the equipment room are 18 flight plan computers, scheduling devices, polar coordinate trackers and acquisition facilities, an automatic voice relay, alpha-numeric video generators, an automatic maintenance facility, a maintenance bench, and power distribution. In the control room, there are six operating consoles—three identical control consoles, a monitor console, a departure console, and a relay console. Functionally, the operation is broken down as follows. The monitor console is the supervisory position. The operator has a time display of the entire scheduling situation and can check on the performance of each aircraft with respect to the schedule. Wind and air density adjustments are made at this position. The three control console operators divide the incoming traffic into three sections, make the initial contact with the aircraft, and assign them to the system. Each operator continues to monitor the aircraft under his control throughout the run. The relay console position is controlled by two operators and has facilities for monitoring the automatic voice instructions. This position is responsible for the hand over to the landing system when the AN/GSN-11 portion of the run is concluded.

To achieve a delivery precision of ± 9 seconds, the GSN-11 utilizes a combination of long-range scheduling followed by gradually tightening closed-loop vectoring.

Aircraft position provided by the radar is supplied to the flight path computer by automatic target-tracking equipment in the GSN-11. On the basis of aircraft flight characteristics (speed, height, etc.), fed in manually from the traffic console during initial acquisition, the computer compares the aircraft's present position with its scheduled time of arrival and determines vector headings and descent instructions necessary for achieving the desired touchdown timing. Computer orders are automatically translated into voice instructions which are radioed to the pilot. The pilot's conformance to instructions is detected by the radar response, which closes the control loop.

The primary technique of controlling an aircraft in order to make it conform to a schedule is one of path stretching. For example, an aircraft reaching the terminal area is assigned an initial arrival schedule which, because of conflict with previously scheduled aircraft, requires that it delays its arrival 180 seconds beyond the earliest time it could reach touchdown. As the aircraft is placed under automatic-voice control, the pilot receives an initial offset heading designed to accomplish most of this delay. However, the aircraft is rolled onto an approximately radial course when it is still 30 seconds early with respect to its arrival schedule. At a precisely calculated point, the aircraft is instructed to begin a single continuous descent from initial to final approach altitude, and is given this instruction at the appropriate time to allow reaching traffic altitude with just sufficient time for slow-down and final approach. As the aircraft comes closer to the airport, its remaining schedule delay is gradually taken out by a slightly curved approach path. As the aircraft nears the turn-on circles, the automatic voice message priorities are increased, enhancing the precision with which the aircraft is controlled, and tightening the control-loop response. At the level-out altitude a last timing correction is made by adjusting the point at which the aircraft is commanded to slow down for final approach. Should

Fig. 1: Typical AN/GSN-11 installation.



the particular approach involve a long turn around the turn-circle, additional schedule control is achieved by moving the turn-circle to which the aircraft is directed.

As aircraft level out on runway line-up, they are transferred to an ILS or GCA approach system, properly spaced not only to prevent overtaking on the final approach, but also to achieve a timing precision of ±9 seconds at touchdown.

Acquisition and Tracking

For maintaining continuous target identifications for the human controllers, and to continuously inform the Flight Plan computers of the position of each aircraft under control, the GSN-11 includes video equipment capable of simultaneously tracking 24 aircraft. Once an aircraft's radar return on the PPI scope is "acquired" by the controller's "light gun," a rectangle of light appears surrounding the target and follows it across the scope. An identifying alpha-numeric symbol is also painted in proximity to each target.

Initial communication with an arriving aircraft is handled through the Traffic Console. The controller selects the desired type of video (Beacon, Normal, MTI) for best target return and points his "light gun" toward the blip of light representing the aircraft. With his left hand, he simultaneously selects the unused tracking-channel to be assigned.

Thereafter, the "range-azimuth" gates generated by the tracker allow only radar video in close proximity to the slewed position to enter the memory circuits. These same gates are used to point the rectangle of light at half-tone brilliance on the radar screen, forming the tracking gate which surrounds the target video.

On each successive sweep of the radar, the range and azimuth gates recenter on the target video gated into the memory circuits. Amount of position change between antenna rotations forms a "velocity" voltage in the memory, which thereafter causes continuous extrapolation of gate position between sweeps. If the velocity extrapolation is perfect, the tracking gate is already recentered when, on the next antenna sweep, target video reappears.

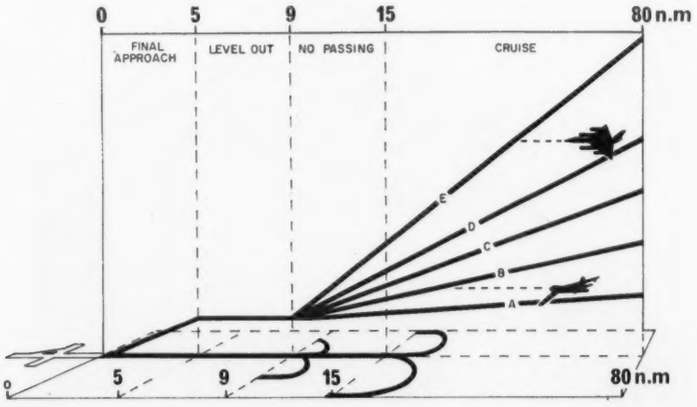
If target video fades on one antenna rotation, the tracking gate coasts on, so as to be centered at the next sweep. If video is absent for 3 rotations, the tracking gate automatically widens to at least twice normal size in order to recapture the lost target. While tracking gate size is adjustable, a typical narrow-gate dimension is 1 mile by 3 degrees.

Scheduling

Based on the arrival geometry and rate of descent glide slopes, the Flight Plan Computer calculates the shortest flight time from the aircraft's present position to touchdown. Since other arrivals are already scheduled, however, their comparison with the new aircraft's time must be made before assigning a schedule. When an aircraft is assigned to a particular glide slope, it remains at altitude until it intersects the descent pattern and then is brought down on a linear time basis. Thus, as the aircraft descends, it is given altitude check points and the aircraft adjusts its descent to keep on the descent pattern. Scheduling criteria can be set up to prevent passing on the same glide slope and when the glide slope altitude separation reduces below a set minimum.

Fig. 3 shows graphically the altitude plan-position geometry as used in the system. Five glide slopes are shown as well as the two-turn-on circles; the larger one for jets and the smaller one for propellers. The 90-mile maximum range shown in the vertical plane is divided into 4 separate zones, each of which is adjustable. Final Approach Zone is under the control of the landing system. A Level Out Zone is provided to allow slow down to final speed and as a minimum altitude for the AN/GSN-11 control. The No Pass Zone is set up so that aircraft on different glide slopes do not pass each other, and the Cruise Zone is the remaining area where passing can be restricted on aircraft which are on the same glide slope. On the horizontal plane are shown two turn-on circles. It must be recognized that aircraft can be coming around these circles while still descending. Also, all zones are indicated with typical dimensions which can be adjusted to suit the situation.

Fig. 3: Functional diagram of the AN/GSN-11 set (explanation in text).



Computing

Controlling each of the 18 inbound aircraft is an identical electromechanical analogue computer. In order to note an aircraft's present position, compare it with a pre-selected arrival schedule, and determine proper control instructions to be radioed via the Auto-Voice synthesizer, a simultaneous solution to a variety of geometrical offset, altitude, timing, and path stretching calculations must be made.

Fig. 4a, b, and c demonstrate the three types of path stretching available in the GSN-11—the Arc-Cosine Beta, the Dog Leg and the Teardrop. In *Fig. 4a* the Arc-Cosine Beta is so named because the offset heading angle is a function of the arc cosine of the error. Utilization of this mode demands many communications with the aircraft to indicate the ever-changing course, but it has the advantage of accuracy that continuous minute adjustment gives. *Fig. 4b* shows the Dog Leg mode. Communications are reduced to a minimum in this mode as the aircraft is sent out on an offest heading and is turned in when its error approaches zero. After the initial Dog Leg pattern, the Arc-Cosine Beta is set in to compensate for small errors remaining. *Fig. 4c* illustrates the Teardrop pattern which is ideal for jet penetrating approaches. The aircraft reports over the beacon at altitude and is assigned a schedule which will bring it down in altitude as it comes to the turn-on circle. This mode permits the control area to be limited to a sector. It is possible to have separate channels using different modes on a number of aircraft simultaneously. In addition to the three path stretching techniques, provision is made for velocity control to take care of small timing adjustments.

Fig. 2: To set up a new approach flight path, the traffic controller aims a beam of light at the radar blip, and simultaneously selects the working channel.

Automatic Voice Facility

The ability of the GSN-11 computer to talk directly to the pilot is of particular importance in relieving controller work load and achieving tight vectoring control. This is accomplished through the Automatic Voice Relay unit, through which the computer selects a correct combination of prerecorded voice phrases by means of relay closures and encoders.

The same radio frequency is used to transmit Automatic Voice messages to as many as three different aircraft. Each message is preceded by an identification word such as "*Bluebird*," "*Cardinal*," etc., indicating the

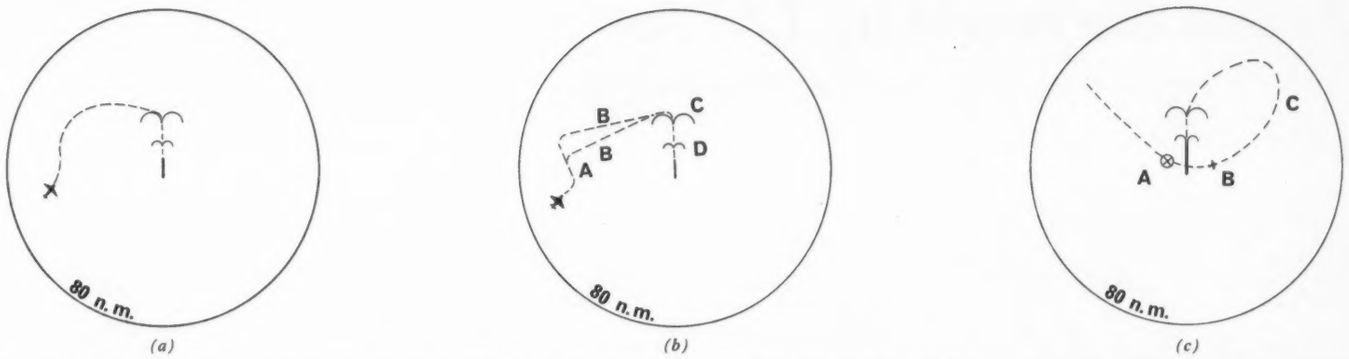


Fig. 4 : The three flight path delay methods. The *arc cosine* method (left) allows constant course corrections to be made through frequent voice radio instructions. The *dog leg* method (centre) is much simpler, as the pilot first holds a delay path (A), which deviates from the direct course, until the calculated delay interval has elapsed, whereupon he is led back (B) into the final approach pattern (Turn-On Circle; C for jets, D for propeller aircraft). The *teardrop* method (right) is specially designed for jet aircraft. After overflying a radio beacon (A) on a set course, the aircraft is taken over by the GSN-11 (B) and is led down the computed flight path (C) to touchdown.

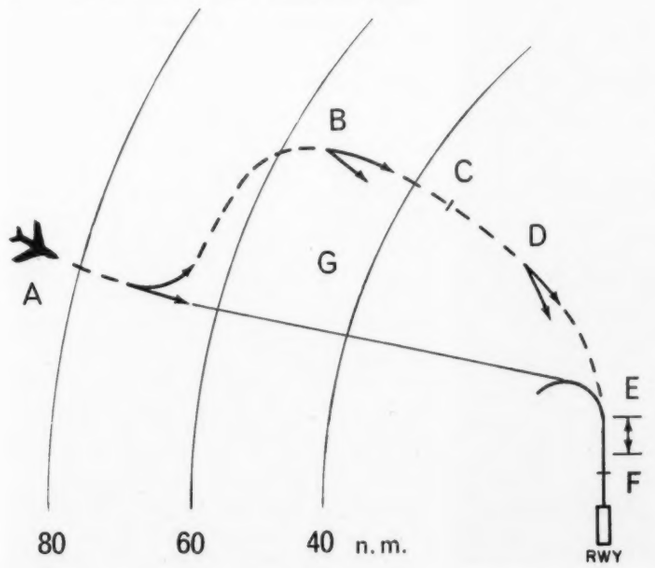
particular aircraft addressed. A priority order of transmission is established between messages of differing importance. For instance, if one flight plan computer requests an emergency turn for "*Bluebird*" simultaneously with the routine altitude checkpoint message "*Cardinal Angels Ten*," the Aout Voice unit automatically transmits the emergency-turn message first, it being of higher priority. If, after this 5 second delay, the programmed altitude for "*Cardinal*" is still within 200 feet of *Angels Ten* (10,000 ft) this less important 2½ second message will be next transmitted. The Automatic Voice has a vocabulary of 25 different types of message, with almost unlimited numerical combinations therein. An interchangeable priority order is established between message types. Other advantages of the AVU include uniformity of message intonation and accent, and the possibility of handling a foreign language. For reliability, two identical 200-channel drums are equipped with automatic switchover in the event of malfunction, and the message-forming circuitry includes extensive malfunction-detection provisions.

Other Useful Control Facilities

Apart from the essential control features already described the equipment has certain other advantages inherent in it which should not be overlooked:

(a) through being primarily developed for the US Air Force, the equipment provides the ability to control large-scale military return-to-base operations under all-weather conditions, and also high-precision control of a single jet approach. This could be of great value in civilian air traffic control also;
(b) only conventional UHF-VHF radio is required;
(c) aircraft can be accepted at any position at random and are not obliged to report at a limited number of fixed points;
(d) aircraft are scheduled according to their optimum performance characteristics with in-flight time delays consequently reduced to a minimum;
(e) the system is able to deliver aircraft to the entry gate of a final approach system within a standard deviation of plus or minus 9 seconds of schedule time. In theory, this permits a rate of 120 aircraft per hour, though 60 per hour is quoted as 'completely safe', according to the Chief of AFCRL's Control Sciences Laboratory. This figure is twice the peak traffic handled by the best of today's large civil airports under IFR conditions.

Fig. 5: Example of an AN/GSN-11 controlled approach.



Terminal Area Control with the AN/GSN-11

The AN/GSN-11 system is dependent on a man-machine relationship where both play an important part in the overall control picture. The most flexible and reliable computer is still the human being. In this system, the controller plays a vital role, first in adapting the system to the particular problem; and second, in serving as the backup in emergencies and equipment failure. In the adaptive role, he must assign tracking gates, set up parameters on the area, weather, and aircraft characteristics, and must accept control from some other system and turn over control to the landing system. In the emergency and backup role, he must give preferential treatment to aircraft in the emergency condition, use manual techniques should the equipment fail, monitor collision possibilities and keep a watchful eye on aircraft in the area which are not under control of the system.

High traffic rates and more efficient systems are going to demand sacrifices on the part of everyone involved in the control picture. Aircraft will be told how to fly and will be restricted in their flight patterns, controllers will have to give up their routine tasks to the more efficient and large capacity electronic computers, and aircraft arrival and departure schedules will have to be subjected to a flow control or queuing is bound to result.

By landing aircraft faster, the GSN-11 reduces the number of aircraft aloft, and cuts congestion in the terminal area. Its pilot-procedures are fast and simple, minimize manoeuvering, and allow pilots to remain safely at high-altitude until time for an uninterrupted descent to the runway.

Economic Considerations

The complexity of the system raises the question of economic practicality. Several factors indicate that this system approach is, in fact, a most inexpensive and effective way to handle the terminal area problem. To begin with, the AN/GSN-11 is channelized, consequently, the total number of units deployed at any given airport can be chosen according to the traffic density. In operation, the equipment drastically reduces the waiting time for departure aircraft and the time in a stack for arriving aircraft. With proper flow control, stacks can be eliminated entirely, permitting aircraft to fly directly in without holding. In effect, this equipment provides traffic handling capacity in IFR conditions which is practically equal to that in VFR conditions, thus getting rid of the traffic bottlenecks that occur with weather problems. Controlled altitude descent and scheduling to touchdown permits aircraft to remain at altitude as long as possible, providing substantial fuel economies especially for jet aircraft. In addition, the controller's routine job is accomplished automatically, thereby reserving the controller's judgment and action for the unusual or emergency situations, which results directly in greater safety and greater efficiency. ◆◆

Round the World by TAI Jet

Tahiti, Cross-roads of the Pacific ... and Far-flung Paradise

by Georges Février, Interavia, *Paris*

Shall I ever return to Tahiti?

Tradition demands that, when leaving Tahiti, you cast into the sea the garlands of flowers put round your neck by those who are staying behind. If they float back towards the shore, it is a sure sign that you will one day return.

But if it is easy to throw these flowers over a ship's rail, if it is still possible to do so through the door of a *Catalina* or of a *Bermuda*, there could be no question of re-opening the airtight door of F. BUIZ, the TAI DC-8 carrying me far from the Happy Isles.

Eleven years ago, I reconnoitred the France-Polynesia route, flying in a *Constellation* and in a DC-4 via Southern Asia, Australia, New Caledonia, the Fiji Islands, and the Cook Islands. At the time, my friends and I covered some 31,250 miles—145 hours' flying in 19 days. We spent four days at Papeete.

I then wrote "... the *Constellation*—this express—linking Paris to Saigon in 32 hours (a remarkable feat) is only a step. It is still not fast enough. Tomorrow people will want to fly from Paris to Indo-China (now Viet-Nam) in a single stage, covering these 7,500 miles in one day, and with better things in mind."

It is not difficult to make prophecies in aviation! The only risk is that progress will overtake your predictions.

Once again, I have experienced a flight round the world—the first to be made under the French flag—timed so that the arrival date at Tahiti of the TAI (Compagnie des Transports Aériens Intercontinentaux) aircraft coincided with the official opening of the runway at Faaa (a genuine Tahitian name, not a typographical error!).

Here is the outline of this world-tour: 13 days' overall, 61 hours' flying, and 9 days in the islands! It marked the culmination of the efforts of the TAI, which can at last utilize its jet aircraft along its complete Paris-Los Angeles route, via Iran, Pakistan, India, Viet-Nam, Indonesia, the Fiji Islands, Tahiti and Honolulu—the longest route in the world. An agreement with Air-France, which charters a TAI machine once a week for use on its Paris-Los Angeles route, allows the traveller to go right round the world, partly astride the Equator, and on one and the same aircraft flying the *tricolore*.

We are indeed far from the DC-4s and the *Catalinas* which used to pick up the passengers from Paris at Noumea.

A unique runway

At the beginning of its operations in the Pacific, TAI used the Morumite runway (built by the Americans during the war) on Bora Bora Island in the Leeward group; the flight from Bora Bora to Tahiti was made by seaplanes, which took off and alighted on the lagoons. But Bora Bora, perhaps the most beautiful island in the world, has very limited hotel resources. And the break in order to get to Papeete, especially after a long journey by jet, would not have been very palatable to the passengers.

In 1956, France started to envisage the construction of a runway at Papeete. But Georges Meunier, Director of Aerial Bases at SGAC, and his staff, very soon established that it would be impossible to plant an aerodrome on the tiny volcanic island of Tahiti, where there is no plateau. Then they decided to build up part of the coral reef at Faaa a few miles outside the town itself, to raise it "out of the water." The work, which had been started at the beginning of 1959, was entrusted to the Société Française d'Entreprise de Dragages et de Travaux Publics. In October 1960, the runway, made of basaltic rock from the river Pumaru, coral, clay, pebbles, and lastly 5 ft of concrete, was used by the TAI DC-6s and DC-7s (these machines used to connect at Noumea with the DC-8s from Paris). It has just been extended to 11,000 ft. The total cost was three thousand million old francs.

Since the runway is built near the seaplane base, the buildings already in existence can still be used, but a new airport and hangars (costing 650 million old francs) are under construction. They will be ready in 18 months, and at the same time an ILS and a radio-communications centre are to be installed.

The remaining islands of the Polynesian Archipelago, namely the Leeward Islands and the Society Islands, are at present served by a Short seaplane operated by RAI (Réseau Aérien Interinsulaire, affiliated to TAI). But seaplanes are hardly being produced any longer... nor are there many seaplane pilots to be found. Accordingly, the construction of small runways (e.g. at Raiatea) suitable for DC-3s, and later on for *Super Broussards*, is under consideration.

The 11,000-ft-long runway at Faaa has been entirely reclaimed from the lagoon; it is situated in the west of the island and runs SW-NE. In the background can be seen the town of Papeete.

A far-flung paradise

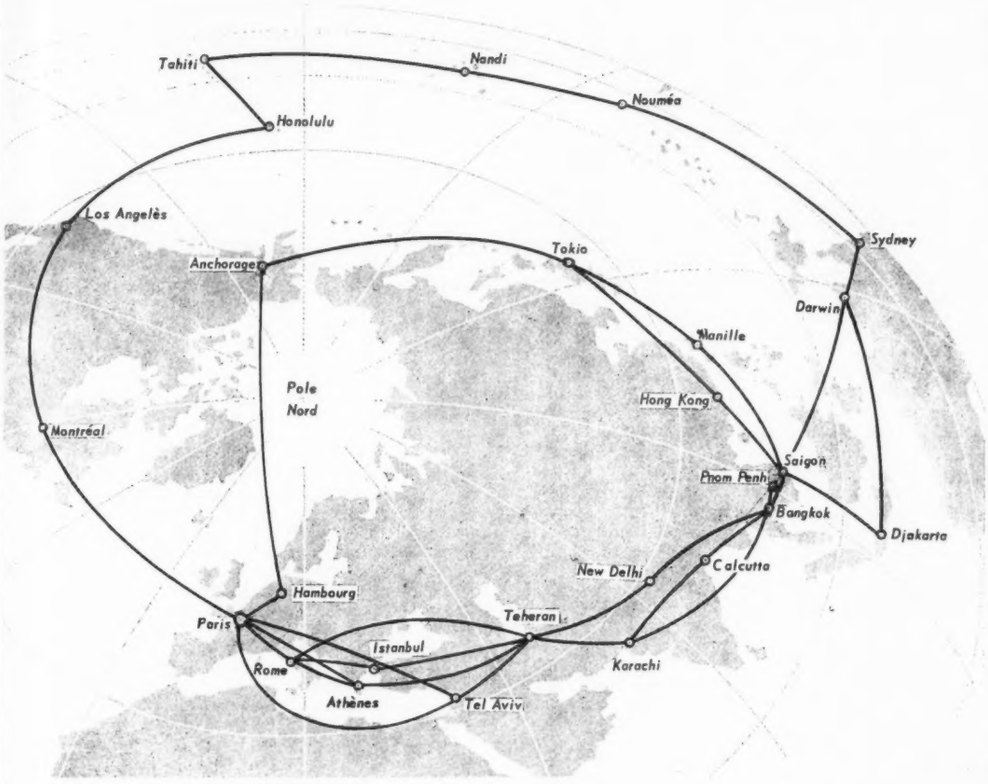
But, as you can easily imagine, the Society Islands and the Leeward Islands have many points of interest apart from the runway at Faaa, unique as that may be.

The incomparable beauty spots, the magic of the colours, bounteous nature, and the warm and smiling hospitality of the local inhabitants, make these islands a real paradise.

Do you know a place on earth where the weather is practically always fine? Where, in spite of the luxuriant vegetation, neither wild animals nor snakes are found? Where the insects do not bite and bathers are protected from sharks by an impenetrable barrier of multi-coloured coral? Where, last but not least, the inhabitants are not commercially minded? In fact, they scorn and despise money to such an extent that I have seen dancers push away with their bare feet ten-dollar bills thrown to them by tourists.

Eleven years ago I wrote: "The very distance of these islands—45 to 50 days journey by sea from any point in Europe—has preserved them as they were at the time of Cook and Bougainville, unmarred by civilization. Will aviation not spoil these places by opening them up to international tourism?"

For three years, TAI has been regularly exploiting the France-Polynesia route and every week TEAL *(Electras)* and SPAL *(Super Constellations)* deliver tourists from Australia,



The two *tricolore* routes round the world.

New Zealand, and the US West Coast. And it goes without saying that TAI's even faster jet service will bring a substantial increase in the flow of tourists.

I believe, however, that my fears were not justified. Firstly, the authorities have wisely limited the height of buildings to three storeys, and have required hotels to be built in traditional Tahitian style. Secondly, and most important, there is the Tahitian outlook on life, of which I have already given an instance, and which is confirmed by the hotel registration form to be filled in upon your arrival, which reminds you that "Tipping is contrary to the laws of Tahitian hospitality: please conform to this custom."

OUR TRIP ROUND THE WORLD

	Distance (miles)	*Flying Time*
Paris-Montreal	3,563	7 h 35
Montreal-Los Angeles	2,594	5 h 20
Los Angeles-Honolulu	2,585	5 h 30
Honolulu-Papeete	2,755	5 h 35
Papeete-Nandi	2,320	4 h 45
Nandi-Noumea	812	2 h
Noumea-Sydney	1,290	3 h 10
Sydney-Port Darwin	1,980	4 h 25
Port Darwin-Djakarta	1,530	3 h 40
Djakarta-Saigon	1,200	2 h 35
Saigon-Bangkok	475	1 h 20
Bangkok-Karachi	2,350	4 h 45
Karachi-Teheran	1,140	2 h 50
Teheran-Rome	2,437	5 h
Rome-Paris	750	1 h 50
	27,781 miles	60 h 20 mins

Like Jules Verne's Phileas Fogg, we gained a day by going round the world from East to West and crossing the dateline between Papeete and Nandi.

You would humiliate and anger your porter or laundress by proffering the traditional tip. This contempt for money (it is true that little enough is needed: fruits and coconuts are common property and the fish need no bait) is the best safeguard of Tahiti's idyllic way of life.

The perfect holiday

In making the journey to Tahiti a matter of a mere ten hours from Los Angeles or Sydney, and a day and a half from Paris (24 hours flying time), TAI opens up new and superb horizons for you. You will be enchanted by the singers and dancers, you will be able to explore the tepid waters of the lagoons and discover fish of colours that are beyond the wildest imagination of a painter. You can enjoy superb fishing, sail in a canoe or motor boat, and also explore other islands even wilder and more beautiful than Tahiti. The inter-island air service RAI (Réseau Aérien Interinsulaire) will take you to Bora Bora, Raiatea, to the Touamotous and to the Gambier Islands. There is only one disadvantage: life is so pleasant in this paradise that perhaps you will be tempted to remain there.

One further word of advice. If you come home by the "long route" (Australia and the East Indies), stay for a few days at Noumea and at Bangkok. The Island of Pines and the Klongs of Thailand will remain as unforgettable memories.

Tahiti, the cross-roads of the Pacific

In the Pacific, as elsewhere, air transport has transformed and will continue to change the life of the population. For example, during the past year the air companies throughout the Pacific offered more than a million seats, while the shipping companies offered only 150,000 bunks.

This year, the introduction of the TAI DC-8s into service will improve the balance of air transport even further. Relatively short journey times (considering the distances involved), excellent service, and a superb cuisine are further arguments to persuade the tourists from Europe, America, and Australia to spend their vacations in Papeete . . . which will soon have its own golf course.

But soon visitors will be coming from other continents. Tahiti is, in fact, the crossing point of the routes between North America and Central and Latin America on one side, and Japan, China, South-East Asia, and Australia on the other.

That tireless "discoverer" of airfields, Colonel Louis Castex, has already prepared a map which foresees the connections Tokyo-Tahiti via Wake Island and Canton; Tahiti-Santiago (Chile) via Mangareva and Easter Island, a route which could be extended to South Africa via Buenos Aires and Tristan de Cunha; Tahiti-Acapulco; and Tahiti-Lima via Hao. The sector Hao-Lima is 3,632 nautical miles, and the crossing would be perfectly feasible. if an airfield existed at Hao, as TAI carry out a weekly service between Los Angeles and Tahiti, a distance of 3,505 nautical miles.

This remote little island, this far-away paradise, will soon be the cross-roads of the Pacific Ocean. ⟷

We stop at Honolulu. Left to right: M. Carour, General Manager of Messageries Maritimes; General Fayet, Chairman of TAI; Messrs J. Roos, Chairman of Air France, and G. Meunier, Director of Air Bases at SGAC: Mme. Roos.

The charming invitation of the Tahitian dancers to join the dance.

Bitte anschnallen...

Please Fasten Your Seat Belts

Flying is a serious enough affair, but it would be the last straw if pilots lost their sense of humour. One who has certainly not done so is Flight Captain Rudolf Braunburg, the author of a good-humoured, pleasantly illustrated, pink-bound little book entitled "Bitte anschnallen" and just published by Kumm-Verlag, Offenbach am Main. Whether flying an old freighter from Hamburg to Munich or crossing the Atlantic in a jet-liner, Captain Braunburg has the knack of seeing the funny side of both piloting and ATC. For the amusement of our non-German-speaking readers, we are presenting a few extracts in translation.

The Editors.

An anxious passenger on his first flight asked the stewardess to hold his hand, which she did. On the return trip, however, she politely declined the same request. "Sorry, Sir, but I have to perform this service in the cockpit—this time it's our Captain's maiden flight."

... When a flight is called, the situation is reminiscent of the intermission bell at the theatre. At this point, therefore, let us give the uninitiated some—hitherto unpublished—illustrations of the loudspeaker announcement ritual. First call: "Please proceed to the exit" should be understood as "There's still time for several elaborate cocktails at the airport bar". Second call: there's still time for a straightforward drink, such as a gin and tonic, particularly if the barman is not already engaged in mixing a flip (an activity which takes up quite some time because of the eggs involved). Third call: quickly order something uncomplicated or actually start paying, according to whether the announcer used the word *last* or *final*.

*

... Whenever a large number of aircraft arrive over the airport in bad weather conditions, they are directed into a so-called holding area, where each aircraft circles around at its allotted level. From time to time, the lowest aircraft is called down to land, whereupon all the others on the merry-go-round slip down one step, like the packets in a cigarette-machine. Once upon a time, the topmost aircraft, number eight on the waiting-list, became impatient and put a request over the radio for ground control to put a spurt on, as fuel reserves were gradually running low. "Sorry," replied control tower, "but all the chaps in front of you are in much the same position. You must wait your turn." For the ensuing half hour, not a sound was heard from the plane, and all attempts to make contact were in vain. Then, at last, up came No. 8" over the radio: "O.K., we're back !" "Why the hell have you kept silence all this time?" snapped control. "My apologies" replied the pilot, "We just made a quick landing to refuel, but now we're up top again, and can comfortably wait another five hours."

"Pay now! Fly later!" ... Don't we dimly remember having this slogan, or the like, before?

*

... One day we landed at Athens, and after the crew had split up into two unequal parties, the larger contingent pushing off to the beach at Piraeus, and the smaller wending its way to the Acropolis, there seemed to be nothing in the way of a return to antiquity ...

To ensure a perfect conducted tour of real cultural and historical value, we had engaged a student from the Academy of Art, who was equally at home in ancient archaeology and modern English. This was the first mistake. Professional pilots are at one with postmen, secretaries, shop assistants, and indeed many other trades, in that the last thing they want to do off duty is talk shop. So, once the door of the cockpit had closed behind us, our one consuming desire was to abandon ourselves entirely to the architectural mysteries of the Propylaeum, the Erechtheion, and the Parthenon. The late-afternoon sun was bathing the Temple of Nike in ochre-coloured light, and a trace of gold flickered above the gable of the Temple of Athene. We were gazing at the steep steps leading to the gateway. It was at this point that our student enquired: "Did you fly over from Germany? Isn't that rather expensive?" We pointed out that, on the contrary, we had actually been paid for coming. "Oh," said our guide, looking at me intently, "so you're a steward."

False pride is not one of my failings, but I felt myself compelled to set the record straight. This was mistake number two, for it set off the now delighted student: "Isn't that wonderful ! I'd like to switch over to aerodynamics. And, tell me, what does the hydraulic system of the *Super-Constellation* look like? Is it really true that ...?"

And so the conversation turned into a game of question and answer, which could well serve as a type sample of a political discussion ... I refer, needless to say, to the fact that from then on our exchanges were entirely at cross-purposes.

We : Doesn't the design of the temples go back to the prehistoric Megaron dwellings?

Student : Yes. Can you lower an airliner's undercarriage even if the hydraulic system fails?

We : Yes. What exactly is the tympanum of a temple?

Student : The triangular framework formed by the cornice of the gable. Is it possible to shut off a damaged leaking circuit with a valve? I should imagine ...

We : With the cross-over valve. Are we right in thinking that the Erechtheion wasn't completed until after the death of Pericles?

Student : Yes, that's right. Would you mind making me a sketch of how a hydraulic system works? ...

And so we found ourselves scratching away with a stick in the venerable sand of the Acropolis, drawing vent pipes, return-valves, pressurisers, regulator pumps, and suction-connections, and one of us stood on the sacred steps of the Parthenon, using arms, legs, and fingers to demon trate how the retraction mechanism of the *Super-Constellation* landing-gear works. When we finally descended the tourist-thronged steps, we had arrived at the air-conditioning plant via the lubrication system and the efficiency of the propellers.

*

... I made the acquaintance of *that* major in the good old days of flying, that is about two years ago, before the Boeing had reduced the complex North Atlantic crossing to the status of a mere medium-haul run of four hours ... Our first differences of opinion cropped up when, at an altitude of 20,000 ft, we pointed to some rows of lights far below us and explained to the major: "The landing runway at Shannon Airport in Ireland!" The major looked suspiciously at each of us in turn and ventured an estimate: "We're still pretty high, eh?" "What do you mean, high? This is a nonstop flight to Canada!"

"Impossible!" said the major.

"How come?" We asked.

"Because there's duty-free whisky waiting down there !" said our major.

No one knew this better than we, but unfortunately the headwinds were not so well disposed towards us at every crossing as to necessitate an intermediate landing in Shannon for refuelling.

"I'm going down the other end !" said the major, now adopting a threatening tone, "and if this damned machine isn't standing on the ground in Shannon within 20 minutes, I'll tear the whole thing to pieces with my bare hands. Take it or leave it !" ... Eighteen minutes later, we rolled to a halt on the runway at Shannon.

The layman who now assumes that, like hunting and fishing, flying has its own special jargon, should on this occasion turn his attention to the fire-warning system of a modern passenger liner. This device, which announces an engine fire, suddenly went into action with a red lamp and a shrill bell. In other words, number three engine was on fire, an occurrence which had no mean effect on whisky sales that evening. Although there was no trace of fire in the engine, we stopped it as laid down in the operations manual, and proceeded to land on this most promising airport with a rush which certainly infringed all existing regulations. We knew for whom the bell had tolled and, although ground checks established that the fire alarm had been caused by an electrical short circuit, supplies of VAT 69 and White Horse had been assured.

The major, for his part, was full of praise. "Top-hole invention, that whisky bell" was his enthusiastic comment.

"Fly longer! More time to eat! ... by SLOW-AIR, the slowest airline in the world."

Book Reviews

Space Trajectories. — Edited by T. C. Helvey. — Academic Press Inc., London and New York, 1960 (English; 298 pages with numerous illustrations, tables, and diagrams; price $12.00).

The American Astronautical Society, the Advanced Research Projects Agency, and the Research Division of Radiation, Inc. sponsored a two-day symposium, held on December 14-15th, 1959, whose aims were a comprehensive survey and exchange of ideas in the field of space trajectory analysis; the papers presented at these meetings, together with the edited discussions, are presented in this volume.

The arcane complexities of space navigation and trajectory computation are reviewed in the precise, but arduous, language of the new astronautic disciplines. Some of the main subjects covered are: astrodynamics, computer programmes for space missions, space-borne computer design, space manœuvres, orbit determination, and re-entry problems.

These matters are treated in some detail, and the liberal use of formulas, diagrams, and graphs, along with the expository text, confers a survey-in-depth character to this volume, which can render valuable reference service to the practising engineer or scientist; it is not likely to gather dust on the shelf after a perfunctory perusal.

The well-educated layman will glean a few interesting facts from this book, and he will gain a better superficial understanding of space vehicle trajectory problems, but he will not derive maximum benefit, as much of the material will be beyond his ken. EE.

Jet Tanker. — By Lt. Col. Grover Heiman, USAF.— Holt, Rinehart and Winston Inc., New York, 1961 (English; 189 pages; cloth-bound; price $3.50).

This story of the experiences of a young officer, co-pilot in a jet tanker crew, gives an interesting picture of air-refuelling operations of the Boeing KC-135 *Stratotanker*, of the long hours of practice flying, and of the incidents which arise during such training. This entertaining and, at the same time, instructive book will leave the reader in no doubt that training in Strategic Air Command is hard but essential. Des.

It's Further Via Gibraltar. — By Patrick Gibbs. Faber & Faber, London, 1961 (English; 144 pages; price 15s; clothbound).

"Get away from the scene of the crash, as far and as fast as you can. Burn your aircraft and then run like hell. And head South. Spain's the place to make for; remember that it may be further via Gibraltar, but it's a lot safer than trying to cross the Channel." So ran the Air Ministry advice which the author, then a fighter pilot in the RAF, followed when his *Spitfire* was shot down in the Pas de Calais area in July 1941.

We are offered a straightforward account of how a courageous and resourceful officer made his way across occupied and unoccupied France, and thence through Spain to Gibraltar. His first attempt took him as far as the Pyrenees and was accomplished with the selfless help of individual French citizens he happened to encounter. The story ends ten weeks after it begins, with Gibbs again visiting the Pas de Calais area—piloting his own fighter. A book for those with a taste for wartime reminiscence and for younger people who enjoy adventure. MT.

Human Factors in Jet and Space Travel. — Edited by S. B. Sells and Charles A. Berry. The Ronald Press Company, New York, 1961. (English; numerous graphs, tables and illustrations; 386 pages; price $12.00.)

The editors of this book, who also contribute three of the sections, have assembled contributions from eleven authors who are specialists in particular fields of aviation medicine. The range of topics covered in the fourteen sections is illustrative of the continued efforts that are required on the part of the flight surgeon, engineer, psychologist, and physiologist, if man is to extend the horizons of flight.

Many of the problems encountered and overcome by military aviation in the realms of high speed and high altitude flight are unknown to the jet passenger of today. That they have been met and overcome is evidenced by the existence of the commercial jet aircraft. Similarly, man's first tentative steps into space present problems of adaptation to enable him to face a hostile and little known environment.

The scope of the contributions, ranging as they do from medicine to engineering, is itself indicative of the manifold problems to be solved. The accent, however, is not on space flight alone. Many of the articles have current application to commercial aviation and to aircraft design today. The contributors have made no attempt to "write down" to a popular public but the material is perfectly comprehensible to the interested layman. For this reason, the editors are to be congratulated on preparing this work, for the topics covered make it absorbing reading. EE.

Lezioni sulla scienza del progetto degli aeromobili. — By Professor G. Gabrielli. Levrotto & Bella, Turin, 1961 (Italian, 273 pages, profusely illustrated).

Professor Gabrielli, well known as the Head of Fiat's Divisione Aviazione as well as for his theoretical studies in the field of aeronautics, needs no introduction to the readers of *Interavia*. This is the first volume of the textbook of his course at the Turin Polytechnic, and, in the author's words, deals with some fundamental aspects of aerostatics and aerodynamics, including a substantial chapter dealing with scale model tests. A second volume, dealing specifically with aircraft, will follow next year. EE.

Lexikon der Hochfrequenz-, Nachrichten- und Elektrotechnik. — Volume 5 (of dictionary). — Edited by Curt Rint. — Porta-Verlag KG, Munich and Verlag Technik, Berlin, 1961 (English, French, Russian; 409 pages; price DM 19.80).

The volume in question is the fifth and final one of this dictionary of technical terms in the high frequency, communications, and electro-technical fields. The first four volumes catalogued the German terms, incorporating careful definitions in German plus—in each case—the equivalent English, French and Russian terms. This volume cross-indexes the terms in each of the four languages separately and, in conjunction with the first four volumes (it is of no value alone), enables translation from any of the languages into any other; at the same time, it adds some new or revised terms (asterisked), which are not contained in the earlier volumes. For German-speaking users, this work undoubtedly meets an important need. In English-speaking countries, however, its practical value is probably limited largely to specialized reference libraries or for users with a good knowledge of German. MT.

Energy Theorems and Structural Analysis. — By J. H. Argyris and S. Kelsey (co-author of Part II).— Butterworth & Co. (Publishers) Ltd., London, 1960 (English; 85 pages; price 21s).

Over six years ago, a series of articles was published in Aircraft Engineering magazine, dealing with basic methods of structural analysis and their application in aeronautical engineering. In view of the persistent demand for reprints of the various individual articles, the author was led to arrange them in book form, corrected and brought up-to-date with references to recent literature.

As stated in the preface, this text is limited to energy principles of analysis, for structures and materials within the elastic range, whether or not they respond in the strictly linear manner of Hooke's Law. Stability problems are not explored.

The first part deals with the concept of strain energy in general. It concludes with a discussion of the various methods based on the principles of virtual displacement and virtual work (Castigliano, Unit Load, and the approximate methods of Rayleigh-Ritz and Galerkin). The main part of the book is devoted to strain energy methods, which go back to Mueller-Breslau in part, and which have long been used in civil engineering. The applications of matrix methods in the analysis of structural problems are developed with particular thoroughness, as they provide a means of handling highly statically indeterminate systems with only relatively elementary mathematics. The substantial calculations is no handicap in this age of electronic digital computers. The numerous illustrative examples in the aeronautical engineering field should be welcome to both students and practising engineers. In the second part—which was earlier the appendix, and whose scope and content requires only 13 pages—are to be found special applications of the previously derived methods to the calculations of thermal stresses (the examples worked are a thin-walled ring and a rectangular plate), and finally, to torsion stresses in thin sections. Pr.

Die Berechnung von rotierenden Scheiben und Schalen. —By Kurt Löffler.—Springer-Verlag, Berlin/Göttingen/Heidelberg, 1961 (German; 241 pages; 92 illustrations; price, clothbound, DM 42.—).

As chief of the engine dynamics division of the Daimler-Benz Company in Stuttgart, the author is well acquainted with the problems faced by the practising designer. Although its presentation is highly mathematical, the book avoids questions of purely theoretical interest, and primarily emphasizes design methods applicable to rotating bodies, which are the key components of compressors and turbines. The table of contents lists such subjects as: . . . disks of uniform thickness . . . disks of non-uniform cross-section . . . vibration stresses . . . disk warping . . . application of matrix calculation methods to the design of rotating disks with no plane of symmetry . . .

Inasmuch as the text is clear and logically organized, the author may be commended for having attained the goal he set himself, which he thus describes in the introduction: ". . . to set forth the applications of well-known calculation methods to the design of asymmetrical rotating disks in such a manner that the practising engineer will lose his fear of complicated differential equations." Ge.

Technische Strömungslehre. — Sixth revised Edition. — By Bruno Eck. — Springer-Verlag, Berlin/Göttingen/Heidelberg, 1961 (German; 453 pages; 454 illustrations; cloth-bound, price DM 31.50).

The fourth and fifth editions of this work ("Theory of Flow for Engineers") have previously been reviewed in detail in these columns, and it is only necessary to mention here that the work has again been brought up to date. In particular, progress achieved in recent years in the field of the dynamics of gases is marked by revision of the relevant sections, and the chapter on the phenomena of separation has been expanded.

At the same time, to keep down the length of the volume, out-of-date matter has been expunged. This book is much esteemed amongst engineers and students, and the determined efforts of those responsible to keep it abreast of developments is much appreciated. Ge.

Handbuch der Astronautik. — Volume 1, instalments 5 and 6—Edited by Karl Schütte and Hans K. Kaiser.—Akademische Verlagsgesellschaft Athenaion, Dr. Albert Hachfeld, Constance, 1960 (German, English; 32 pages each; one and two tables respectively; numerous illustrations; paperback; price DM 5.20 each).

Here are two further instalments in the series of admirable contributions on space research, nos. 1-4 of which were reviewed in *Interavia* 12/1960, page 1572. Instalment no. 5 (in English) concludes the chapter on heat transfer problems in liquid-propellant rockets by J. Smith and George P. Sutton, and is directed mainly to specialists. This is followed by Robert P. Haviland (in English) on the applications of artificial satellites (earth survey, meteorological observation, communications, etc.) which is, on the other hand, of more general interest. Starting in no. 5 and concluding in no. 6 is a contribution by J. Eugsters (in German), which deals with his investigation into the very topical subject of cosmic radiation and its significance for manned spaceflight. Also in no. 6 is part of a thorough investigation into basic rocket theory (in German) by W. Alvermann and W. Lohse. Numerous diagrams, drawings, and photographs are provided, and simplify the various articles for the reader. Later instalments will include contributions by Siegfried J. Gerathewohl and Krafft A. Ehricke. De.

Lufttüchtigkeit. Prüfung und Zulassung des Luftfahrtgerätes. — Volume 7 of the series: Die Bücher der Luftfahrtpraxis.—By Josef Matschego.—Hanns Reich Verlag, Munich, 1960 (German, 176 pages).

Where technical matters encroach on our everyday life—and they do so more and more all the time—they affect the interests and rights of every human being and accordingly become the object of legal regulation. This gives rise to a link between two systems of science and philosophy which are completely strange to each other. In this age of constant striving after specialization, it becomes more and more difficult to bridge the wide gap between technicians and lawyers, and to find a common language.

This book succeeds in closing a gap of this kind. With the growing complexity and larger number of aircraft in daily use, stringent requirements must be laid down as to their operational safety. Such safety is, of course, in the public interest and therefore falls within the scope of legislative bodies. While the engineer is responsible for the preparation of the basic technical principles and their constant updating, it is for the jurist to codify the pertinent regulations and to incorporate them in legislation.

As the Head of the Airworthiness Section of the Federal Aviation Office, the author is certainly the expert in West Germany best qualified to deal with both the technical and legal aspects of the testing and certification of aircraft. The first part of this book, which is within the layman's grasp, acquaints the reader with general technical questions. With constant reference to international regulations, the author takes care not to lose himself in detail, but attaches much more importance to fundamentals and to explanatory comment. This section should prove particularly valuable reading for all those who are prone to ascribe excessive costs and time-consuming certification procedures to administrative pettifogging. The second part is devoted to current laws and regulations in force in West Germany. Here, the technician will find the regulations of importance to him, with comments thereon.

All in all, a carefully balanced, well-rounded presentation of a subject affecting all those who design, build, or operate aircraft. While the book is understandably oriented toward German requirements, it should also be of interest abroad, especially in countries exporting to Germany aviation *matériel* which requires certification at destination. Pr.

Flieger-Jahrbuch 1961. — Edited by Heinz A. F. Schmidt. Transpress VEB Verlag für Verkehrswesen, Berlin, 1960 (German; 172 pages; numerous illustrations; clothbound; price 14.80 DM).

This fourth issue of the Flight Yearbook contributes interesting material concerning civil aviation in Eastern European countries. For example, Rudolf Rónai, General Manager of Civil Aviation of the Hungarian People's Republic, gives a detailed description of the Hungarian air transportation system, and Jan Zwierzynski, Director of the Civil Aviation Administration in the Ministry of Transport of the Polish People's Republic, presents a clear description of civil aviation activities in Poland. The following articles will be found particularly valuable by those who are interested in technical matters: development of the Dresden 152 jet airliner and its power plant; survey of STOL and turboprop aircraft; introduction to astronomical navigation. Sports flying enthusiasts will find a description of the newest private aircraft and sailplanes, and an article on sports flying in Bulgaria. Needless to say, no article is without its allusions to the advantages of the socialistic organization of economic activity. Aside from this, the good photographs, some of which are in colour, and the clear drawings in this yearbook all contribute to make it an interesting survey of aviation behind the Iron Curtain. De.

Elsevier's Dictionary of Electronics and Waveguides, Russian Supplement. — By W. E. Clason. — Elsevier Publishing Company, Amsterdam/London/New York/Princeton, 1961 (Russian; 57 pages; price D.M. 24.—; paper-back).

This is a supplement to the Dictionary of Electronics and Waveguides in six languages, already reviewed in *Interavia* 3/1958, containing the corresponding Russian technical terms. The expressions given in the original work are numbered serially and the Russian equivalents in the volume under review bear corresponding numbers. There is, accordingly, no difficulty in translating any of the Russian words and expressions listed into any of the six languages covered by the original dictionary. Eb.

Sa Majesté Caravelle. — By Olivier Pech. — Editions France-Empire, Paris, 1961 (French, 285 pages).

This work by Olivier Pech of Sud-Aviation offers a somewhat unusual mixture of highly reliable source material, nicely spiced with humour, and a certain sense of heroism and grandeur. The *Caravelle* is an aircraft which is the fruit of persistence and of the creative spirit, and this book covers its history from the first working drawing to the use of the aircraft in commercial operation. As a good illustration of the achievements of modern industry, this book will contribute to popularizing aeronautics. Pi.

Civil Engineering Reference Book (Second Edition).— Edited by J. Comrie. — Butterworth & Co. (Publishers) Ltd., London, 1961 (English; 4 volumes, about 500 pages each; numerous graphs, tables, and drawings; price, complete, £17.17s).

The headlong pace of technological progress in all engineering fields materially shortens the useful life of the reference texts upon which the practising engineer relies for information and guidance in the solution of problems lying outside of his own area of specialization. In the decade since this valuable reference work was first published, certain trends in modern life have accentuated and accelerated the demands which must be satisfied by civil engineering works. The population explosion, for example, creates new needs for water and power supplies, while in transportation, higher land and air speeds render highways and airports obsolete before they have time to "wear out."

It is felt that in certain key areas this second edition needs strengthening and further updating; it lacks emphasis on airports, highways, water supply, and sewage and industrial waste treatment. Sixty pages are devoted to railways, which is as much as is assigned to highways and airports together; yet today the latter constitute the vast majority of all construction in the field of transportation. In the airport section, the advent of jet aircraft is marked by only one sentence, and the reader is referred to an ICAO publication for much of the design procedure of runway pavements for multi-wheeled undercarriages. Heliports are not mentioned, nor are ancillary airport facilities, such as underground hydrant fuelling systems adequately described.

The sections on water supply and coastal engineering are too narrowly oriented toward British problems, and such significant developments in breakwater protection as tetrapods are barely mentioned. Modern techniques in the selection of design wave heights for marine structures are only hinted at, despite their importance today as offshore platforms for radar devices and oil drilling rigs.

The applications of electronic computers to such fields as highway planning and design are omitted, although their use in structural design is covered in one paragraph.

In brief, although this handbook already covers an unusually wide range of topics, it needs further expansion in certain fast-growing areas of the civil engineering profession, to match the growth in its scope. Despite this critical comment, it is felt that this text offers an excellent treatment of the more classical and theoretical aspects of civil engineering, and most of the authors are world-renowned specialists in their field. Du.

Books received

Publications of the Institut du Transport Aérien, ITA, Paris, 1961:

Frontiers and the Revolution in Transport, by Jean Mercier.

Study 61/7: Comparative Study of Nine European Airlines' Traffic and Financial Results, by Geo Besse.

NT 339: Future STOL Possibilities from U.S. Helicopter-Airline Experience.

NT 340: Air/Road Service Stations to Further Private Flying.

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LETTER TO THE EDITOR

Sir,

An article by Dipl.-Ing. Büller correctly describes and identifies by name the Grunberg hydrofoil watercraft in the April '61 issue of *Interavia* (" 'Hydrooil Craft of Today and Tomorrow ").

A few paragraphs later, in obvious reference to the same configuration, the article makes a far less valid statement. It says, " the vessels developed according to this method were saddled with the defects of both types—the cavitation of underwater wings and the sensitivity of glide wings to waves." The inference is—while some hydrofoil boats cavitate but are insensitive to the state of the seas, and other craft are affected by the waves but enjoy freedom from cavitation, Grunberg merely compounds their objectionable features, without sharing in the merits. The facts are quite to the contrary.

In the first place, the premise is not correct. No watercraft has succeeded so far in completely subtracting itself from the disturbances created by rough seas, and this holds true of the "variable area" (or "waterpiercing") hydrofoil boats preferred by Mr. Büller. Nor can lift-producing hydrofoil avoid cavitation when performing beyond their operational reach, generally limited by velocity. So, why "saddle" the Grunberg system with all the sins and absolve, at least partly, its rivals?

In the second place, a quantitative comparison between the water-piercing hydrofoils and the Grunberg fully submerged hydrofoils reveals that of the two, the former are more vulnerable to cavitation and ventilation to boot. I might add that one particular version of the Grunberg system totally eliminates cavitation and ventilation, regardless of speed. But that is a different story, it does not belong here.

Either Mr. Büller did not have first-hand information on the behavior of the Grunberg system, or else his data were obtained from a nonrepresentative, inefficiently designed watercraft. My own experience contradicts his implications. From the outset, I achieved excellent seaworthiness, and there is room left for further improvements. The point which I wish to make is—what Mr. Büller calls the "glide wings" of the Grunberg configuration encompasses a broad assortment of variously shaped bodies, not necessarily wings. While some shapes may be greatly affected by the waves, others are remarkable in their ability to cushion the wave impacts. A designer has, in addition, other parameters to bring into play in improving the sea-going qualities of a craft. This can be, and has been, achieved with the Grunberg system. Mr. Büller claims that Supermar A.G. have found a way of optimizing in a similar manner the operation of another type of hydrofoil craft. Excellent news! But it only lends weight to my point.

The Grunberg configuration is not a thing of the past, of merely historical interest. It is prepared to meet any good competition; but it could be discredited, and progress itself undermined, by unwarranted adverse publicity, particularly when given by a publication of *Interavia's* circulation and standing. I am confident, Mr. Editor, that in all fairness you will find it necessary to prominently display my refutation.

While on the subject, may I bring to attention two less consequential inaccuracies in the cited article?

(1) I never intended to perfect Forlanini's concept, whether in the original form (essentially retained by Bell), or as evolved into Crocco's design, the forerunner of most modern water-piercing configurations. In fact, the two approaches, Forlanini's and Grunberg's, are basically different. One stabilizes by variation of the immersed area, the other uses constants area/variable angle of attack hydrofoils. I might add that I was not even aware of any earlier experiments, until I conceived my system and searched the literature for possible antecedents.

(2) My first experiments were conducted in the midthirties, not in the twenties, as asserted in the article.

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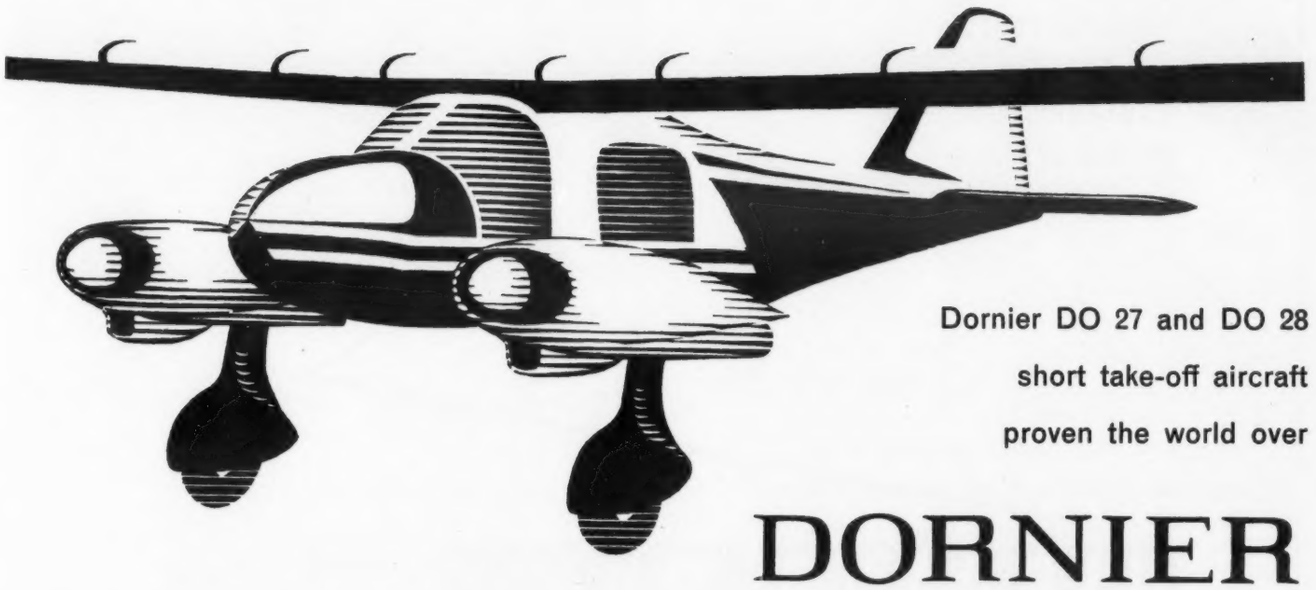

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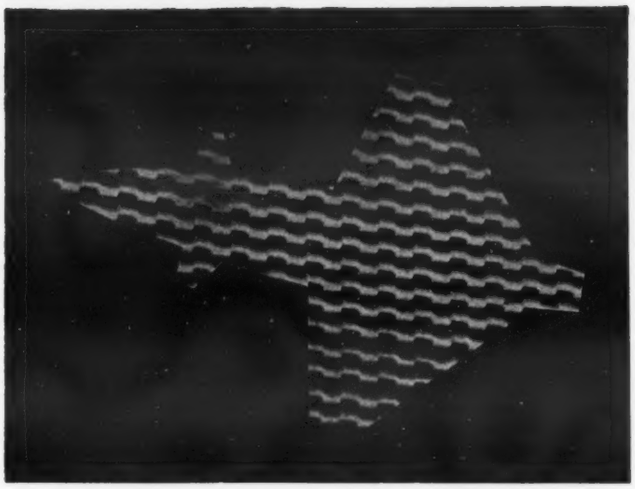

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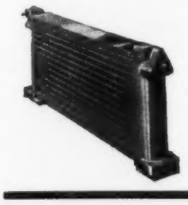

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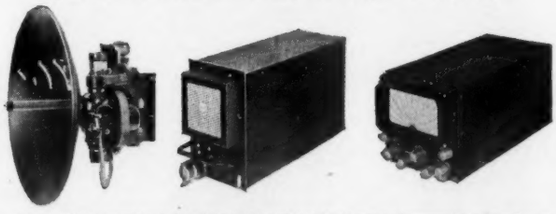

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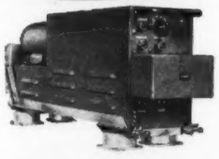

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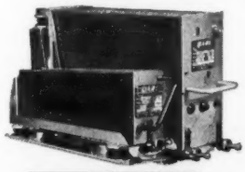

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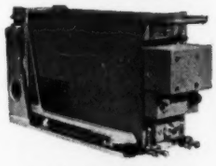

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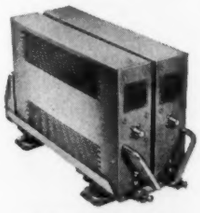

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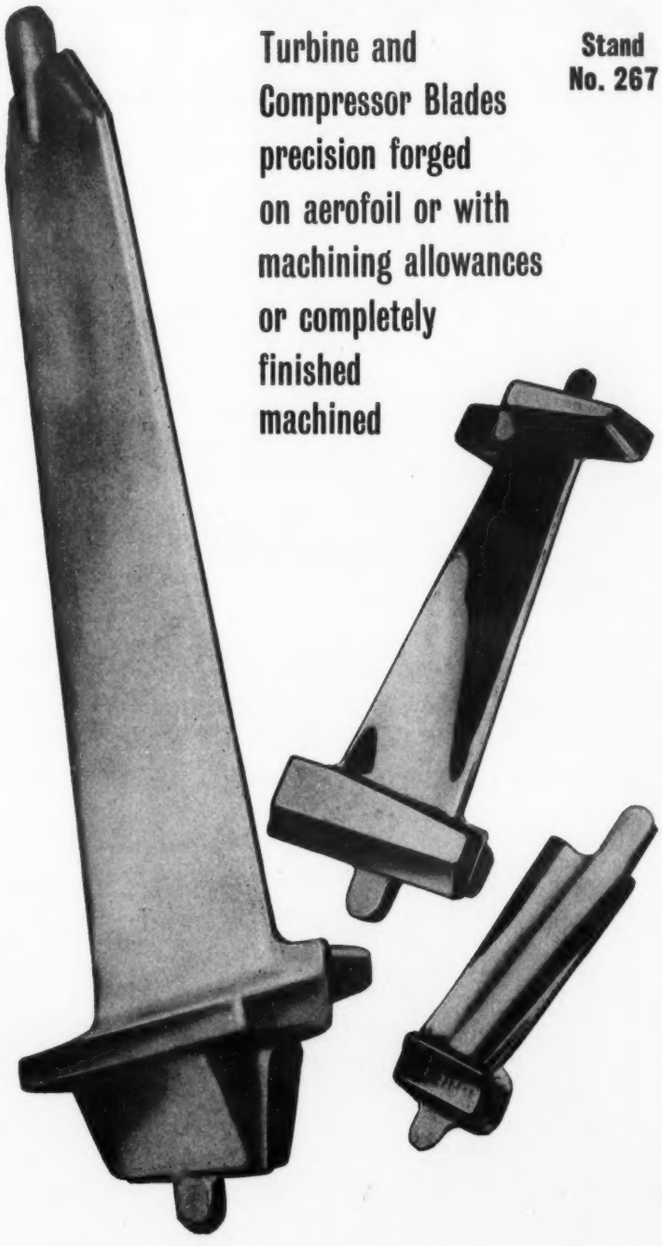

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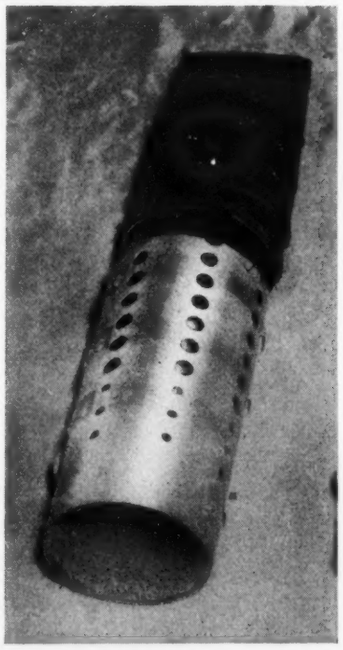

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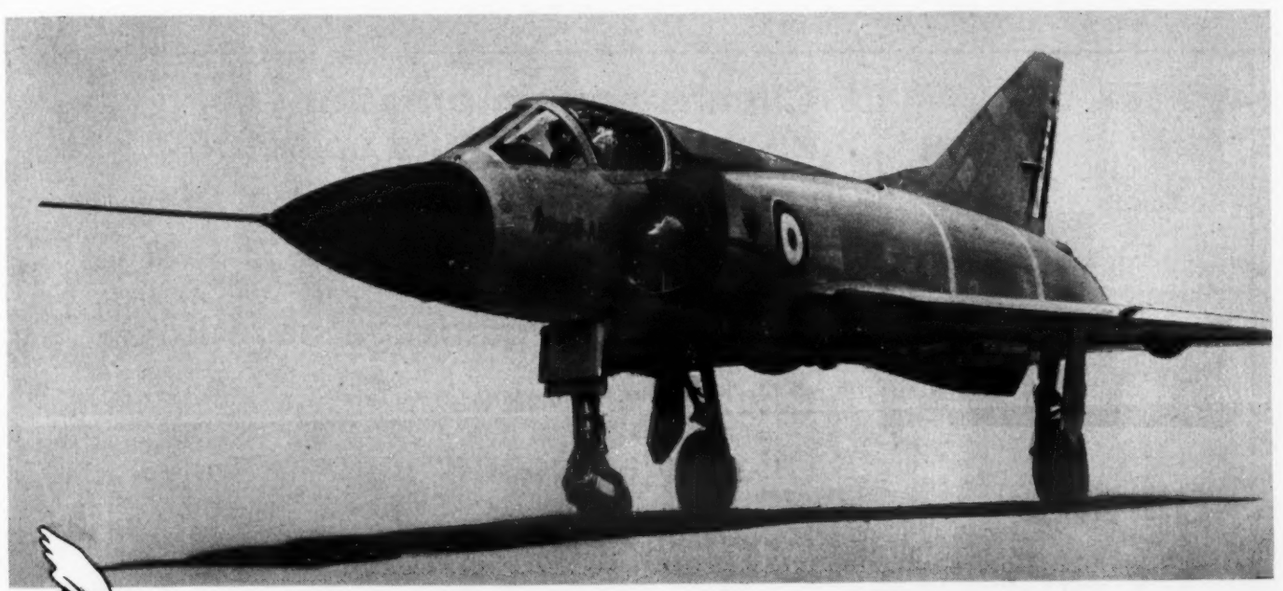

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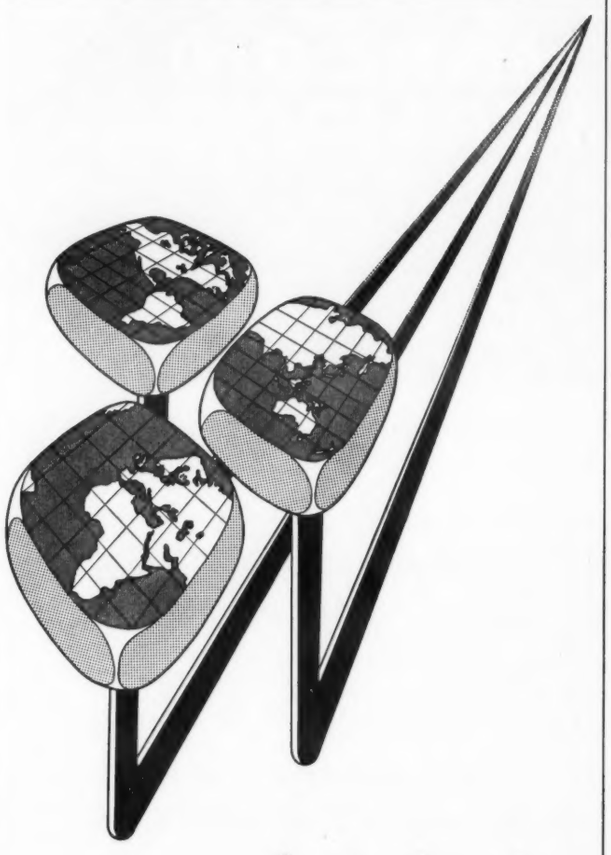

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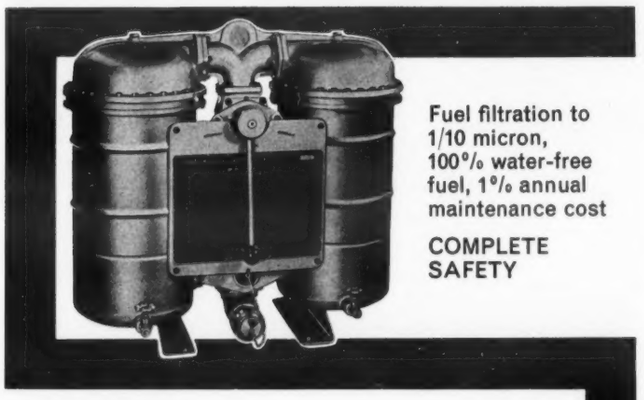

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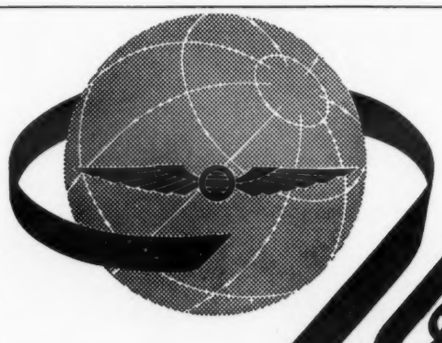

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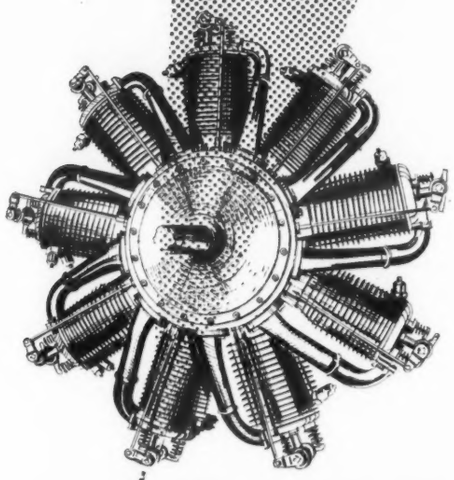

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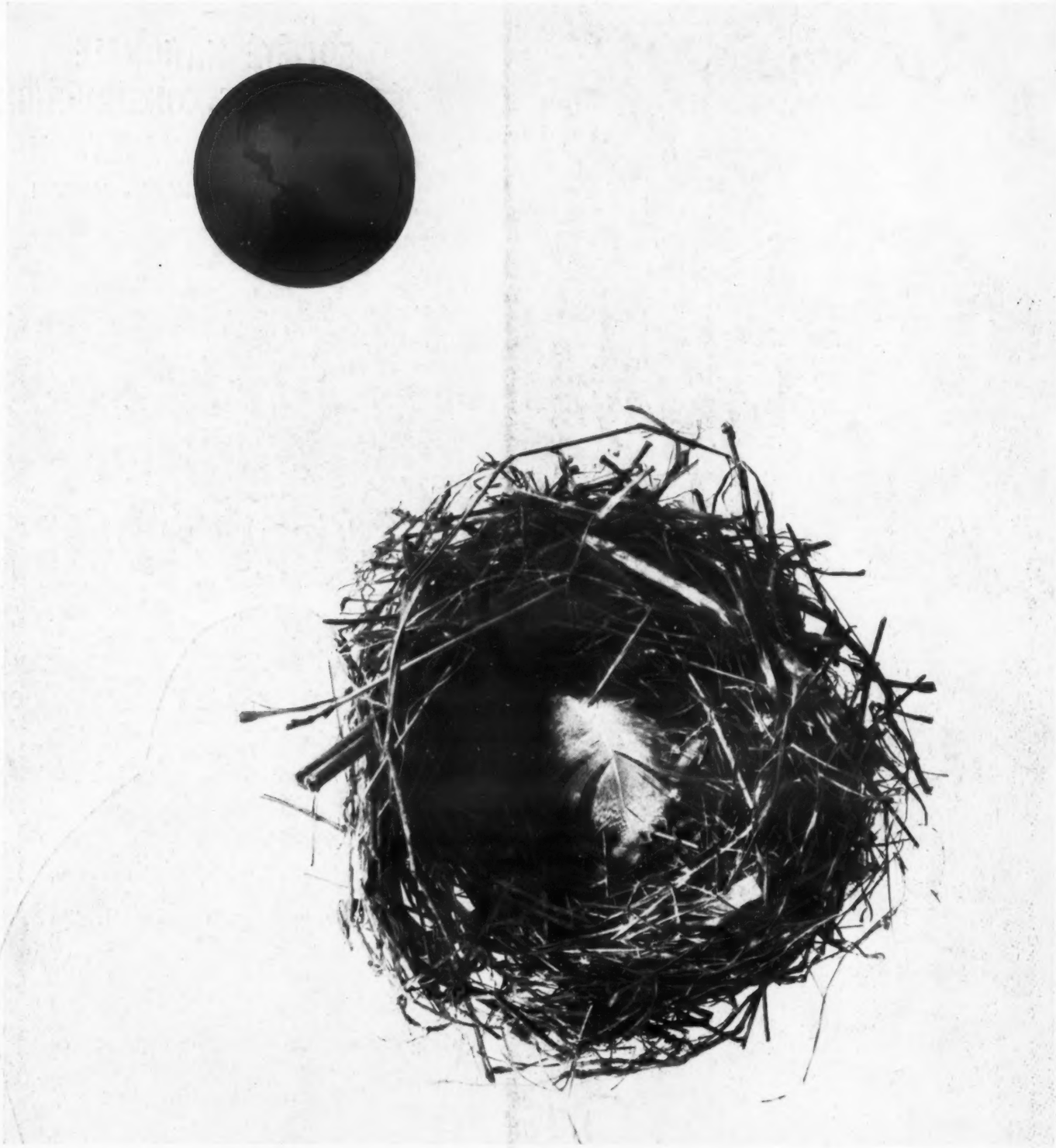

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